

**EXPANDED SITE INVESTIGATION
QUALITY ASSURANCE SAMPLING PLAN**

FOR

**SAN MATEO CREEK BASIN URANIUM LEGACY SITE
NEAR GRANTS, CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO**

Prepared for

U.S. Environmental Protection Agency Region 6

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1 INTRODUCTION

Weston Solutions, Inc. (WESTON®), the Superfund Technical Assessment and Response Team (START-3) contractor (EPA team), has been tasked by U.S. Environmental Protection Agency (EPA) Region 6 Prevention and Response Branch (PRB) under Contract Number EP-W-06-042 and Technical Direction Document (TDD) Nos. 35/WESTON-042-14-001 and 19/WESTON-042-13-001 (Appendix D) to conduct an Expanded Site Investigation (ESI) within the San Mateo Creek drainage basin located near Grants, Cibola and McKinley Counties, New Mexico. The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) number assigned to the site is NMN000606847. The EPA team has prepared this ESI Quality Assurance Sampling Plan (QASP) to describe the field investigation activities, sampling, and analytical scope of work to be conducted as part of the TDD requirements.

1.1 PROJECT OBJECTIVES

The EPA team is providing technical assistance to EPA Region 6 for the performance of the ESI. The objective of the ESI is to sample and evaluate alluvial groundwater conditions within the San Mateo Creek drainage basin.

The objective of the ESI will be achieved by evaluating data obtained during the field investigation through the collection of groundwater samples from existing and newly installed monitoring wells located in the San Mateo Creek Drainage Basin.

1.2 PROJECT TEAM

The EPA team will consist of Jeff Criner, the EPA team Assessment/Inspection Manager; Derrick Cobb, the EPA team Project Team Leader (PTL); Olin Garren, EPA team Field Operations Liaison; Ben Castellana, the Quality Assurance Officer; Kristie Warr, Project Chemist and Data Management (DM) support; and additional EPA team members as necessary to assist with sample collection, sample preparation, and packing.

The EPA team PTL will be responsible for the technical quality of work performed in the field and will serve as the EPA team liaison to the EPA Task Monitor (TM) during the field activities. The PTL, with the concurrence of the EPA TM, will determine the precise location for sample collection in the field, collect samples as necessary, log the activities at each sample location in the field logbook, and verify the sample documentation. The DM will be responsible for entering all samples collected into the Scribe Environmental Sampling Data Management System (SCRIBE), producing accurate chain-of-custody documentation for the samples during the ESI, and entering daily operations and sample collection data into EPA Response Manager. The PTL will oversee the packaging and shipping of samples to the designated subcontract laboratories. The PTL will also be responsible for providing overall site health and safety support during field activities.

1.3 QASP FORMAT

This ESI QASP is organized as follows:

- Section 1 – Introduction
- Section 2 – Site Background
- Section 3 – Field Investigation
- Section 4 – Analytical Approach and Data Validation
- Section 5 – Quality Assurance

All figures are included as separate portable document format (PDF) files.

2 SITE BACKGROUND

Information regarding the site location, description, and geological setting, including operational history and ownership, is presented in the following subsections. This information was obtained from the New Mexico Environment Department (NMED) Groundwater Quality Bureau document titled *Site Inspection Report Phase 2, San Mateo Creek Basin, Legacy Uranium Mine and Mill Site Area, Cibola-McKinley Counties, New Mexico, dated April 2012*.

2.1 SITE LOCATION AND DESCRIPTION

The San Mateo Creek Basin (Hydrologic Unit Code [HUC] 1302020703), by which the boundary of the Site is defined, comprises approximately 321 square miles within the Rio San Jose drainage basin in McKinley and Cibola counties, New Mexico. This basin is located within the Grants Mining District (GMD), which is an area of uranium mineralization occurrence approximately 100 miles long and 25 miles wide encompassing portions of McKinley, Cibola, Sandoval, and Bernalillo counties and includes the Ambrosia Lake Mining District. Main access into the Site is provided via New Mexico State Roads 605 and 509.

The 85 legacy uranium mines with recorded production and 4 legacy uranium mill sites comprising the Site may have contributed to degradation of groundwater quality within the basin. Some background groundwater contaminant concentrations associated with remediation of the Homestake Mining Company (HMC) Superfund Site (HMC Site: NMD007860935) exceed federal and state drinking water standards as well as state groundwater standards.

2.2 GEOLOGIC SETTING

The alluvial system extends from the northeast to the south of the HMC Site, following the San Mateo Creek drainage. The southern end of the San Mateo Alluvial system has been impacted by contamination from the HMC Site. Underlying the Alluvial Aquifer in this vicinity is the Upper Triassic Chinle Formation, which is a predominantly shale formation 800 feet in thickness. Three aquifer units are present within this formation in the southern part of the basin.

The highest two aquifers are the Upper and Middle Chinle sandstones. The lower aquifer, the Lower Chinle, is fractured shale with variable hydrologic yield of generally poor quality water. All three of these aquifers subcrop with the Alluvial aquifer connecting the Alluvial aquifer and each of the Chinle aquifers hydrologically in the vicinity of the HMC site. The San Andres regional aquifer underlies the Chinle Formation in this area.

Most uranium production in New Mexico has come from the Upper Jurassic Westwater Canyon member of the Morrison Formation north of the HMC site in McKinley and Cibola counties. This unit consists of interbedded fluvial arkosic sandstone, claystone, and mudstone with an average thickness of 250 feet, thinning to 100 feet southward and westward, and is a major aquifer with the GMD. Three types of uranium deposits that are found in the Westwater Canyon member are primary (trend or tabular; average ore grade greater than 0.20% uranium oxide [U_3O_8]), redistributed [stack; average grade 0.16% U_3O_8], and remnant-primary (average grade 0.20% U_3O_8). The overlying Brushy Basin member of the Westwater Canyon member includes the Poison Canyon Sandstone, from which uranium also has been mined.

Additionally, uranium deposits were discovered at Haystack Butte in 1950 within the Upper Jurassic Todilto Limestone, which occurs within the San Raphael Group underlying the Morrison Formation; these accounted for approximately 2% of production from the Grants Uranium District between 1950 and 1981. More than 100 uranium mines and occurrences in the Todilto Limestone are documented in New Mexico, with production reported from 42 of these mines - mostly located within the Grants Uranium District.

Thin zones of minor uranium mineralization have been produced from shale and lignite within the Lower Cretaceous Dakota Sandstone, which overlies the Morrison Formation. Uraniferous collapse-breccia pipe deposits, which are vertical or steeply-dipping cylindrical features bounded by ring fractures and faults filled with heterogeneous brecciated country rock, also are found in the Grants area.

Quaternary-age unconsolidated to semi-consolidated alluvial, eolian, and terrace deposits overlie bedrock in valley bottoms; these deposits are generally less than 200 feet in thickness.

2.3 OPERATIONAL HISTORY AND OWNERSHIP

Uranium ore was discovered in the Todilto Limestone at Haystack Butte in 1950, and production began prior to mill construction in the area by open-pit mining. Uranium was discovered at Ambrosia Lake in 1955. Downdip drilling from the initial surface discoveries delineated ore bodies within the Poison Canyon and Westwater Canyon members of the Morrison Formation. The discovery of large subsurface uranium deposits within the Westwater Canyon member resulted in the establishment of two-thirds of the active uranium mines in New Mexico within the Ambrosia Lake district by 1980; most of these mines were underground room-and-pillar operation at depths averaging 900 feet.

The Anaconda Copper Company built the Bluewater Mill in 1953 to process ore from the Jackpile Mine. This mill used a carbonate-leach process with a capacity of 300 tons per day and operated until 1959. An acid-leach mill was operated from 1957 through 1982, reaching a production capacity of 6,000 tons per day in 1978. Atlantic Richfield Company (ARCO) reclaimed the site between 1991 and 1995 for long-term DOW stewardship under the Legacy Management Program.

Two mills were built in 1957 at the present Homestake Mill Site. The first closed in 1962. Homestake originally owned the second larger mill in a partnership. When that partnership was dissolved in 1981, Homestake became the sole owner. Mill production ceased in 1981, but resumed in 1988 to process ore from the Section 23 Mine and Chevron's Mount Taylor Mine. The mill was demolished in 1990, and the site groundwater restoration is ongoing. In 2001, Homestake merged with Barrick Gold Corporation.

Kermac Nuclear Fuels Corp., which was a partnership of Kerr-McGee Oil Industries, Inc., Anderson Development Corp., and Pacific Uranium Mines Co., built the Kerr-McGee Uranium Mill at Ambrosia Lake in 1957-58. Quivira Mining Co., a subsidiary of Kerr-McGee Corp. (later Rio Algom Mining LLC, currently BH-Billiton) became the operator of the mill in 1983. Operation began in 1958; from 1985 through 2002, the mill produced only from mine water from

the Ambrosia Lake underground mines. The tailing impoundment at the site contains 33 million tons of uranium ore (*sic*) within an area of 370 acres.

Phillips Petroleum Co. built a mill at Ambrosia Lake in 1957-58 and began to process ore from the Ann Lee, Sandstone, and Cliffside mines in 1958. United Nuclear Corporation acquired the property in 1963 when the mill closed. United Nuclear Corporation operated an ion exchange system to extract uranium from mine water in the late 1970s to early 1980s. All operations ended in 1982.

3 FIELD INVESTIGATION

The activities that will be conducted during the ESI are discussed in this section. Monitoring well installation, sampling procedures, locations, analytical approach, and quality assurance (QA) that will be conducted during the ESI are also discussed.

3.1 SAMPLING STRATEGY

The EPA TM, New Mexico Environment Department (NMED), and the EPA team developed a sampling strategy intended to collect the data necessary to evaluate and meet the objectives of the ESI. The sampling strategy focuses on the collection of samples from existing and newly installed monitoring wells located in the San Mateo Creek Drainage Basin. It is anticipated that no sampling on Tribal land will be conducted during the ESI.

A proposed sample location map identifying existing monitoring wells and proposed monitoring wells is presented on Figure 3-1. More detailed maps for proposed monitoring well locations: BG-01, BG-02, BG-03, BG-04, BG-05, BG-06, BG-07, C3, C5, and N1 through N5 are included as Figures 3-2 through 3-10. Existing monitoring wells proposed for sampling include locations: MW-35-7, MW-35-8, SMC10, SMC-11, SMC-12, SMC-13, SMC-14, and SMC-26, SMC-09A, and SMC-09B are included as Figures 3-11 through 3-15. Note that existing wells SMC-09A and SMC-09B are illustrated in Figure 3-6 due to the proximity of proposed monitoring well BG-07. Table 3-1 has been prepared to include a summary of Sample Locations and Sampling Rationale as part of the ESI field effort.

3.2 DATA QUALITY OBJECTIVE

The objective of groundwater and seep sampling activities is to document groundwater conditions within the San Mateo Creek Drainage Basin. To accomplish this, a groundwater data quality objective (DQO) has been developed and is included in Appendix A. The DQO presented was developed using the seven-step process set out in the *EPA Guidance for Quality Assurance Project Plans: EPA QA/G-5*.

3.3 PRELIMINARY FIELD ACTIVITIES

Mobilization and preliminary field activities for the ESI are discussed in the following subsections.

3.3.1 Field Activities Review Meeting

The EPA team PTL will conduct a meeting with the entire field team to familiarize them with the ESI Scope of Work, to discuss EPA TM expectations, including planned field investigation activities, and to review the project Health and Safety Plan (HASP) and other relevant EPA team operating procedures. This meeting will be conducted in WESTON's Houston, Texas, office or via video conferencing for team members in other offices, prior to mobilizing to the field.

3.3.2 Mobilization and Command Post Establishment

The EPA team will mobilize the equipment required for the ESI field investigation from its Regional Equipment Stores (RES) warehouse in Houston, Texas.

The field team will utilize the existing EPA command post located in Grants, New Mexico. Equipment used during the ESI will be stored in the command post or at the EPA soil staging area located approximately 2 miles from the command post. The EPA team will provide sufficient dedicated (nondisposable and disposable) sampling equipment to collect samples in a manner minimizing the number of times that decontamination is performed on a daily basis.

Prior to demobilization, all remaining field supplies and equipment will be transported back to RES.

3.3.3 Health and Safety Plan Implementation

The ESI field activities will be conducted in accordance with the site-specific HASP prepared for this investigation. In general, the HASP specifies that work will proceed in Level D personal protective equipment (PPE) (coveralls, hard hats, and steel-toed boots) in selected sampling areas based on appropriate air monitoring results. The EPA team PTL will serve as the Field Safety Officer (FSO) and will be responsible for implementation of the HASP during field investigation

activities. Subcontractors participating in the ESI will be required to conduct work according to the guidelines and requirements of the HASP. Daily tailgate safety meetings will be held prior to initiation of each work day.

In accordance with the EPA team's general health and safety operating procedures, the field team will also drive the route to the hospital specified in the HASP prior to initiating sampling activities.

3.3.4 Sample Location Reconnaissance

The EPA team shall complete an initial survey of on-site sample locations to verify that sample monitoring well locations have been selected appropriately and choose alternative well locations if proposed locations are inaccessible or if a better sampling location can be found. The FTL will consult with the EPA TM before selecting alternative sample locations.

3.3.5 Residential Property Access and Community Relations

Sampling may be required in locations where access has not yet been obtained prior to the field activities. If the EPA TM is not present in the field during the ESI field activities, the EPA PTL or Field Operations Liaison will manage community relations in the field as directed by the EPA TM.

3.3.6 Documentation of Field Sampling Activities

The EPA team will document the ESI field activities in bound field logbooks. At a minimum, the information documented in the field logbook for each sample location will include the following:

- The sample location number and the depths of sample collection
- A description of the sample location at the site
- A measurement from the sample location to a physical structure
- The sample matrix and sample description
- The analyses for which the samples were collected
- The date and time of sample collection

Locations where samples are collected, including newly installed and existing monitoring wells, will be documented using a global positioning system (GPS) to obtain horizontal control. A registered surveyor will obtain horizontal and vertical control of all newly installed monitoring wells. If requested by the EPA TM, the registered surveyor will also obtain horizontal and vertical control of all existing monitoring wells sampled if surveyor information is not available.

3.3.7 Decontamination and Investigation-Derived Wastes (IDW)

The nondisposable sampling equipment (groundwater sampling pumps, water measurement instrumentation, etc.) used during the sample collection process will be thoroughly decontaminated before initial use, between locations, and at the end of the field investigation before leaving the site. Decontamination activities will be conducted at the soil staging area. Equipment decontamination will be completed in the following steps:

- High-pressure water spray or brush, if needed, to remove soil from the equipment
- Nonphosphate detergent and potable water wash to clean the equipment
- Final potable water rinse
- Equipment air dried

Equipment used during drilling activities will be decontaminated by high-pressure steam cleaning prior to drilling and between each location. In addition to steam cleaning between drilling locations, the soil sampling equipment, such as split-spoons, core-barrel samplers, and Shelby tubes, will be high-pressure steam cleaned between each location. This equipment will then be rinsed with potable water before reuse. If deemed necessary, decontamination activities will be conducted at a temporary decontamination pad that will be constructed in an area identified prior to the beginning of field activities.

The fluids and excess soil/sediment generated as a result of equipment decontamination will be containerized and transported back to the soil staging pad. Water generated from the monitor well installation and development activities will be containerized and transported back to the soil staging pad. All soil and decontaminated fluids generated during the ESI field effort will be appropriately disposed of at the end of the project.

3.4 MONITORING WELL INSTALLATION

The EPA team will utilize a State of New Mexico-licensed driller for the monitoring well installation and abandonment activities. Well installation and plugging and abandonment will be in accordance with any EPA and/or State of New Mexico regulations.

The EPA team anticipates utilizing hollow-stem auger and dual-wall air rotary drilling techniques to advance, continuously sample, and install up to 14 groundwater monitoring wells in the alluvial water-bearing zone estimated to be approximately 80 feet to 120 feet below ground surface (bgs). Proposed monitoring wells include locations BG-01, BG-02, BG-03, BG-04 BG-05, BG-06, BG-07, C3, C5, and N1 through N5, all of which are presented as Figures 3-2 through 3-10. The coordinates of the proposed and existing monitoring well locations is included in Table 3-2.

For planning purposes, it should be noted that multiple soil borings may be advanced to identify suitable alluvial groundwater for monitoring well installation and sampling. For example, four boring locations are proposed for location BG-01, and depending on groundwater encountered; only one of those boring locations will be converted to a monitoring well with all other boreholes appropriately grouted to the surface.

Prior to drilling in locations BG-01, BG-02, BG-06, and N3, the EPA team will conduct a seismic survey utilizing Bird Seismic Services of Globe, Arizona. Bird Seismic will complete a high-resolution 2-Dimensional seismic survey and produce a map identifying potential buried stream channels in the San Mateo Basin Creek Basin to optimize the drilling locations.

Prior to the seismic survey, Bird Seismic will deploy geophones along the “seismic line” and connect them via cables to remote seismic recording vehicle. Global Positioning System (GPS) coordinates of each geophone deployed along each survey line will be collected. After the geophones have been deployed, a small all-terrain vehicle (ATV) mounted thumper will drive along the seismic line and thump at each location. The collected velocity data is then recorded, stored on disk, and at the end of the day is sent for post processing.

The EPA Team PTL and the subcontracted driller will work to ensure that there is no unnecessary disturbance to the local surroundings where soil borings and/or monitoring wells are to be installed. The EPA TM and EPA Team PTL have worked to select well locations that are as close to existing roads as possible to reduce unnecessary soil and vegetative disturbance. There are no plans to build any roads to the proposed monitoring well locations on State of New Mexico-owned or private land. The possibility exists that small improvements to some of the dirt roads utilizing a back-hoe or similar equipment could be conducted to level the driving surfaces and allow for drilling rig access. No well pads or mud pits will be needed as part of this environmental investigation. Monitoring wells and/or soil borings will not be advanced on or adjacent to any steep slopes. Any soil cuttings and well development water generated as part of the investigation will be containerized and transported back to the soil staging area for appropriate disposal. Trash will be containerized and transported back to the soil area following completion of each monitoring well.

Each boring advanced will be continuously sampled using a 5-foot long, split-barrel core sampler until terminal depth and classified by the EPA geologist according to the Unified Soil Classification System (USCS). At the completion of each boring, and as noted above, a determination will be made between the EPA TM and the EPA team geologist as to whether to convert the boring into a groundwater monitoring well. If sufficient groundwater is not encountered, no well will be installed, the boring will be immediately grouted as described below, and an alternate drilling location will be selected. If adequate groundwater is encountered in the borehole and a well is to be installed, the EPA TM and EPA team geologist will determine the appropriate screened interval based on field observations. Monitoring well installation details are described in the following subsection.

In lieu of installing a monitoring well due to dry borehole conditions, the EPA TM and EPA team geologist may select to collect soil cores for laboratory analyses. Specific analyses designated for these cores samples are included in Section 4.0.

3.4.1 Monitoring Well Installation Details

Each monitoring well installed will be constructed of 2-inch-diameter, Schedule 40, flush-threaded polyvinyl-chloride (PVC) casing and up to 10 feet of 0.010-slotted screen. The annular space around the screen will be filled with clean, uniform-sized (20 to 40 mesh or similar) silica sand to a minimum height of 2 feet above the top of the screen. A minimum 3-foot-thick layer of bentonite pellets or bentonite slurry will be placed immediately above the sand pack. If bentonite pellets are used, potable water will be poured over the pellets to initiate hydration. The pellets will be allowed to hydrate for at least 30 minutes before grout is added to the borehole. After the bentonite seal is installed, the remaining annular space will be pressure grouted to the surface.

A 5-foot-long, 6-inch-diameter outer protective steel casing with a lockable-hinge cap will be installed 2 to 3 feet into the grout seal. The riser pipe will terminate no more than 4 inches below the rim of the protective casing. A 4-foot-by-4-foot concrete pad will be installed around the outer base of the protective casing. A typical well construction schematic is included as Figure 3-16.

3.4.2 Plugging and Abandonment

Boreholes that do not produce sufficient water will be grouted according to State of New Mexico regulations. All boreholes will consist at a minimum of grout mixture consisting of 6 to 8 pounds of bentonite powder per 94-pound bag of Portland cement, mixed with 6 to 8 gallons of water. The boreholes will be pressure grouted using a tremie pipe from the bottom to the ground surface. The hose will be placed at the bottom of the borehole and raised at a rate so that the bottom of the tremie pipe remains below the top of the grout.

3.5 MONITORING WELL DEVELOPMENT

The newly installed monitoring wells will be developed no sooner than 24 hours after completion using either surge block, submersible pumps, bailers, or other means deemed appropriate by the EPA team geologist and EPA TM. If a submersible pump or bailer is used for well development,

it will initially be set at the bottom of the well, then slowly moved toward the top of the screen or borehole to ensure that water is drawn through all portions of the screened interval.

3.6 MONITORING WELL SAMPLING

A total of 26 groundwater samples (including two duplicate samples) will be collected from the 14 newly installed monitoring wells and 10 existing monitoring wells. All monitoring wells will be sampled following *Low-flow (Minimal-Drawdown) Groundwater Sampling Procedures* described in U.S. EPA document (EPA/540/S-95/504, April 1996) (Appendix B).

Existing monitoring wells to be sampled include the locations MW-35-7, MW-35-8, SMC-09A, SMC-09B, SMC-10, SMC-11, SMC-12, SMC-13, SMC-14, and SMC-26. The locations of these existing wells are illustrated as Figures 3-11 through 3-15.

The EPA team will measure depth to groundwater in each well and then utilize a QED pneumatic pump with dedicated sample tubing to collect groundwater samples. During well sampling, field measurements of groundwater dissolved oxygen (DO), turbidity, pH (± 0.5 units), electrical conductivity (EC) ($\pm 10\%$ $\mu\text{mhos/cm}$), temperature ($\pm 1^\circ\text{C}$) and oxidation/reduction potential (ORP) will be collected and recorded in the field logbook.

The groundwater samples will be submitted to a National Environmental Laboratory Accreditation Program (NELAP) certified laboratory for analyses. Specific laboratory information is included in Section 4 of this QASP.

3.7 DEVIATIONS FROM THE SAMPLING PLAN

Deviations from the sample locations may occur at the EPA TM's direction due to new observations made prior to sampling, information obtained in the field that warrants an altered sampling point, difficulty in sample collection, or limited access. The EPA TM will be notified, and concurrence will be obtained should significant deviations from the planned sampling points be proposed. Details regarding deviations of the QASP will be documented in the site logbook and reported in the final ESI report to EPA.

Table 3-1
Sample Locations and Sampling Rationale
San Mateo Creek Basin Uranium Legacy Site
Near Grants, Cibola and McKinley Counties, New Mexico

Sample Name	Sample Matrix	Sample Location (refer to Figure 3-1)	Rationale
BG01-- YYYYMMDD-21	Groundwater	Drill a monitoring well located upgradient and north of the basin and Section 10 Mine and Ambrosia Lake Mill	Collected to determine groundwater quality
BG02-- YYYYMMDD-21	Groundwater	Drill a monitoring well located upgradient and north of the basin and Section 17 Mine and Phillips Mill	Collected to determine groundwater quality
BG03-- YYYYMMDD-21	Groundwater	Drill a monitoring well located upgradient in the Village of San Mateo Area	Collected to determine groundwater quality
BG04-- YYYYMMDD-21	Groundwater	Drill a monitoring well located upgradient in the Village of San Mateo Area	Collected to determine groundwater quality
BG05-- YYYYMMDD-21	Groundwater	Drill a monitoring well located upgradient in the Village of San Mateo Area	Collected to determine groundwater quality
BG06-- YYYYMMDD-21	Groundwater	Drill a monitoring well located upgradient and east of the basin between Red Point Mine and Section 18 Mine.	Collected to determine groundwater quality
BG07-- YYYYMMDD-21	Groundwater	Drill a monitoring well located upgradient of the basin on the southeast end and north of F-33 and Tom Mines	Collected to determine groundwater quality
N1-YYYYMMDD-21	Groundwater	Drill a monitoring well located on northern end of basin just south of Bucky Mine	Collected to determine groundwater quality
N2-YYYYMMDD-21	Groundwater	Drill a monitoring well located on northern end of basin along Highway 509, south of Section 19 Mine, northeast of Section 30 West Mine, and north of Section 30 Mine	Collected to determine groundwater quality

Table 3-1
Sample Locations and Sampling Rationale
San Mateo Creek Basin Uranium Legacy Site
Near Grants, Cibola, and McKinley Counties, New Mexico
(Continued)

Sample Name	Sample Matrix	Sample Location (refer to Figure 3-1)	Rationale
N3-YYYYMMDD-21	Groundwater	Drill a monitoring well located on northern end of basin southeast of Section 24 Mine, northeast of Section 25 Mine and west of Section 20 West Mine	Collected to determine groundwater quality
N4-YYYYMMDD-21	Groundwater	Drill a monitoring well located on northern end of basin approximately 1.5 miles east of location N2	Collected to determine groundwater quality
N5-YYYYMMDD-21	Groundwater	Drill a monitoring well located on northern end of basin east of Chill Willis Mine	Collected to determine groundwater quality
C3-YYYYMMDD-21	Groundwater	Drill a monitoring well located in central area of basin, north of Moe No. 4 Mine	Collected to determine groundwater quality
C5-YYYYMMDD-21	Groundwater	Drill a monitoring well located in central area of basin on the West side of Hwy 509 and north of the Doris Mine	Collected to determine groundwater quality
MW-35-7-YYYYMMDD-21	Groundwater	Sample existing monitoring well located south of Cliffside, Sandstone and Section 35 Mines	Collected to determine groundwater quality
MW-35-8-YYYYMMDD-21	Groundwater	Sample existing monitoring well located south of Cliffside, Sandstone and Section 35 Mines	Collected to determine groundwater quality
SMC-26-N4-YYYYMMDD-21	Groundwater	Sample existing monitoring well located to the west of Marquez Mine	Collected to determine groundwater quality
SMC-10-52-YYYYMMDD-21	Groundwater	Sample existing monitoring well SMC-12 located in south area of basin north of Homestake Mill	Collected to determine groundwater quality

Table 3-1
Sample Locations and Sampling Rationale
San Mateo Creek Basin Uranium Legacy Site
Near Grants, Cibola, and McKinley Counties, New Mexico
(Continued)

Sample Name	Sample Matrix	Sample Location (refer to Figure 3-1)	Rationale
SMC-11-53-YYYYMMDD-21	Groundwater	Sample existing monitoring well SMC-10 located in south area of basin north of Homestake Mill	Collected to determine groundwater quality
SMC-12-51-YYYYMMDD-	Groundwater	Sample existing monitoring well SMC-11 located in south area of basin north of Homestake Mill	Collected to determine groundwater quality
SMC-13-54-YYYYMMDD-21	Groundwater	Sample existing monitoring well SMC-13 located in south area of basin north of Homestake Mill	Collected to determine groundwater quality
SMC-14-55-YYYYMMDD-21	Groundwater	Sample existing monitoring well SMC-14 located in south area of basin north of Homestake Mill	Collected to determine groundwater quality
SMC-09A-YYYYMMDD-21(Existing well at BG-07 location)	Groundwater	Sample existing monitoring well located near BG-07 location that is upgradient of the basin on the southeast end and north of F-33 and Tom Mines	Collected to determine groundwater quality
SMC-09B-YYYYMMDD-21(Existing well at BG-07 location)	Groundwater	Sample a second existing monitoring well near BG-07 that is located upgradient of the basin on the southeast end and north of F-33 and Tom Mines	Collected to determine groundwater quality

Table 3-2
Sample Locations and Coordinates
San Mateo Creek Basin Uranium Legacy Site
Near Grants, Cibola, and McKinley Counties, New Mexico

WELL	LAT	LONG
BG01A	35.46053563300	-107.88582293400
BG01B	35.46220876400	-107.88537731800
BG01C	35.45819833500	-107.88632156000
BG01D	35.46419185400	-107.88517356900
BG02A	35.44826570600	-107.81338711500
BG02B	35.44833596500	-107.80857433500
BG02C	35.44817438200	-107.81617548800
BG03	35.33604000000	-107.65400000000
BG04	35.34087000000	-107.65249000000
BG05	35.34250000000	-107.65136000000
BG06a	35.35745515500	-107.91817097800
BG06b	35.35747090300	-107.91576020300
BG06c	35.35747744600	-107.91355725800
BG06d	35.35744243600	-107.91140942100
BG07a	35.23800000000	-107.78428500000
C3	35.31555600000	-107.81258200000
C5a	35.36156600600	-107.79209516700
C5b	35.36156859200	-107.79242039600
C5c	35.36156873200	-107.79276397500
MW-35-7	35.37914269330	-107.75541771300
MW-35-8	35.37937637880	-107.76309106700
N1	35.43512406300	-107.85706551800
N2	35.41941599700	-107.82741547400
N3	35.41849771800	-107.84372289400
N4	35.41964387300	-107.81104111100
N5	35.34882360600	-107.75832057600
SMC-9a	35.23776015750	-107.78884076517
SMC-9b	35.23659376190	-107.78878944516
SMC-10	35.27773340280	-107.83081378500
SMC-11	35.27693340360	-107.84416978200

Table 3-2
Sample Locations and Coordinates
San Mateo Creek Basin Uranium Legacy Site
Near Grants, Cibola, and McKinley Counties, New Mexico
(Continued)

WELL	LAT	LONG
SMC-12	35.28943740160	-107.83950478200
SMC-13	35.27547633880	-107.85064189500
SMC-14	35.27518840470	-107.85928377900
SMC-26	35.34657838960	-107.77465579200

4 ANALYTICAL APPROACH AND DATA VALIDATION

Samples collected as part of the San Mateo ESI field effort will be analyzed for both radiological and chemical analyses by a NELAP-certified laboratory. Table 4-1 summarizes the samples that will be collected, including the volumes, container types, and associated analytical methods.

4.1 RADIOLOGICAL ANALYSES

Groundwater samples collected for radiological analyses will include the following:

- Total Uranium (and dissolved) by SW-846 Method 6010
- Alpha Spec: U-234, U-235, U-236, U-238, Th-227, Th-228, Th-230, Th-232 by HASL 300 A-01-R
- Gamma Spec: Ra-226 by SW-846 9315; Ra-228 by SW-846 9320
- Gross Alpha/Beta by EPA 900.0

4.2 CHEMICAL ANALYSES

Groundwater samples collected will be submitted for the following chemical analyses:

- Total Metals (and dissolved) by SW-846 Method 6010
- Mercury (and dissolved) by SW-846 Method 7470
- Total Dissolved Solids (TDS) by EPA Method 160.1
- Anions by EPA 300.0, alkalinity, carbonate and bicarbonate by EPA 310.0, and pH by EPA 150.1

Up to six soil core samples will be collected at terminal depth and analyzed for synthetic precipitation leaching procedure (SPLP) modified EPA Method 1312 for geochemical assessment parameters.

4.3 DATA VALIDATION

The EPA team will validate the radioanalytical data by having each data set reviewed by a professional health physicist. A summary of the data validation and findings will be presented in

Summary Reports as part of the final report. The EPA team will evaluate the following to verify that the radioanalytical data are within acceptable QA/QC tolerances:

- The completeness of the laboratory reports, verifying that all required components of the report are present and that the samples indicated on the accompanying chain-of-custody are addressed in the report.
- The results of laboratory blank analyses.
- The results of laboratory control sample (LCS) analyses.
- Compound identification and quantification accuracy relative to expected isotopic ratios for uranium and its decay products.
- Laboratory precision, through review of the results for blind field duplicates.

The inorganic analytical data generated by the designated laboratory will be validated using EPA-approved data validation procedures in accordance with the EPA *CLP National Functional Guidelines* for Inorganic Data Review (January 2010). A summary of the data validation findings will be presented in Data Validation Summary Reports as part of the final report. The following will be evaluated to verify that the analytical data is within acceptable QA/QC tolerances:

- The completeness of the laboratory reports, verifying that all required components of the report are present and that the samples indicated on the accompanying chain-of-custody are addressed in the report.
- The calibration and tuning records for the laboratory instruments used for the sample analyses.
- The results of internal standards analyses.
- The results of laboratory blank analyses.
- The results of LCS analyses.
- The results of MS/MSD analyses.
- Compound identification and quantification accuracy.
- Laboratory precision, by reviewing the results for blind field duplicates.

Variances from the QA/QC objectives will be addressed as part of the Data Validation Summary Reports.

Table 4-1
Requirements for Containers, Preservation Techniques,
Sample Volumes, and Holding Times
San Mateo Creek Basin Uranium Legacy Site
Near Grants, Cibola and McKinley Counties, New Mexico

Name	Analytical Methods	Container	Preservation	Minimum Sample Volume	Maximum Holding Time
TAL Metals and Mercury	EPA SW-846 Methods 6010 and 7470	Polyethylene	HNO ₃	250 mL	28 days for mercury 180 days for metals
TAL Metals and Mercury (dissolved)	EPA SW-846 Methods 6010 and 7470	Polyethylene	HNO ₃ (After being field filtered)	250	28 days for mercury 180 days for metals
Total Uranium	EPA SW-846 Method 6010	Polyethylene	HNO ₃	250 mL	6 months
Total Uranium (dissolved)	EPA SW-846 Method 6010	Polyethylene	HNO ₃ (After being field filtered)	250 mL	6 months
Anions	EPA 300.0	Polyethylene	4 °C	250 mL	48 hours (for nitrate, nitrite, and phosphate) / 28 days
pH	EPA 150.1	Polyethylene	4 °C	250 mL	Immediately or as soon as possible after receipt at the laboratory
Total Dissolved Solids	EPA 160.1	Polyethylene	4 °C	250 mL	7 days
Alkalinity, carbonate, and bicarbonate	EPA 310.1	Polyethylene	4 °C	250 mL	7 days
Alpha Spec: U-234, U-235, U-236, U-238	HASL 300 A-01-R	Polyethylene	HNO ₃	1 liter	180 days
Alpha Spec: Th-227, Th-228, Th-230, Th-232	HASL 300 A-01-R	Polyethylene	HNO ₃	1 liter	180 days
Gross Alpha/Beta	EPA 900.0	Polyethylene	HNO ₃	500 mL	180 days
Radium 226	SW-846 9315	Polyethylene	HNO ₃	500 mL	180 days
Radium 228	SW-846 9320	Polyethylene	HNO ₃	500 mL	180 days

Note:

¹Field Duplicate Sample will be collected at a rate of 1 per 10 samples collected.

²Equipment Rinsate blanks will be collected at the rate of 1 per week of non-disposable sampling equipment during drilling activities.

³Temperature blanks will be placed in each cooler shipped to the laboratory.

5 QUALITY ASSURANCE

Quality assurance will be conducted in accordance with the WESTON Corporate Quality Management Manual, dated September 2012; the WESTON Programmatic Quality Assurance Project Plan (QAPP), dated December 2009; and the WESTON Quality Management Plan, dated June 2010. Following receipt of the TDD from EPA, a Quality Control (QC) officer is assigned and monitors work conducted throughout the entire project including reviewing interim report deliverables and field audits. The EPA team PTL will be responsible for QA/QC of the field investigation activities. The designated laboratory utilized during the investigation will be responsible for QA/QC related to the analytical work. The EPA team will also collect samples to verify that laboratory QA/QC is consistent with the required standards and to validate the laboratory data received as described above.

All sampling will be conducted following Weston Standard Operating Procedures (SOPs) which are found in Appendix C.

5.1 SAMPLE CUSTODY PROCEDURES

After sample collection and identification, samples will be maintained under chain-of-custody (COC) procedures. If the sample collected is to be split (laboratory QC), the sample will be allocated into similar sample containers. Sample labels completed with the same information as that on the original sample container will be attached to each of the split samples. Personnel required to package and ship coolers containing potentially hazardous material will be trained accordingly.

The EPA team will prepare and complete chain-of-custody forms using SCRIBE for samples sent to an off-site laboratory. The chain-of-custody procedures are documented and will be made available to personnel involved with the sampling. A typical chain-of-custody record will be completed each time a sample or group of samples is prepared for shipment to the laboratory. The record will repeat the information on each sample label and will serve as documentation of handling during shipment. A copy of this record will remain with the shipped samples at all times, and another copy will be retained by the member of the sampling team who originally

relinquished the samples. At the completion of the project, the data manager will export the SCRIBE chain-of-custody documentation to the Analytical Service Tracking System (ANSETS) database.

Samples relinquished to the participating laboratories will be subject to the following procedures for transfer of custody and shipment:

- Samples will be accompanied by the COC record. When transferring possession of samples, the individuals relinquishing and receiving the samples will sign, date, and note the time of the sample transfer on the record. This custody records document transfer of sample custody from the sampler to another person or to the laboratory.
- Samples will be properly packed for shipment and dispatched to the appropriate laboratory for analysis with separate, signed custody records enclosed in each sample box or cooler. Sample shipping containers will be custody-sealed for shipment to the laboratory. The preferred procedure includes use of a custody seal wrapped across filament tape that is wrapped around the package at least twice. The custody seal will then be folded over and adhered to seal and ensure that the only access to the package is by cutting the filament tape or breaking the seal to unwrap the tape.
- If sent by common carrier, a bill of lading or airbill will be used. Bill of lading and airbill receipts will be retained in the project file as part of the permanent documentation of sample shipping and transfer.

5.2 PROJECT DOCUMENTATION

Documents will be completed legibly in ink and by entry into field logbooks and SCRIBE as described above. Response Manager will be used after direction of the EPA TM.

5.2.1 Custody Seal

Custody seals demonstrate that a sample container has not been tampered with or opened. The individual who has custody of the samples will sign and date the seal and affix it to the container in such a manner that it cannot be opened without breaking the seal.

5.2.2 Photographic Documentation

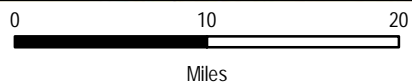
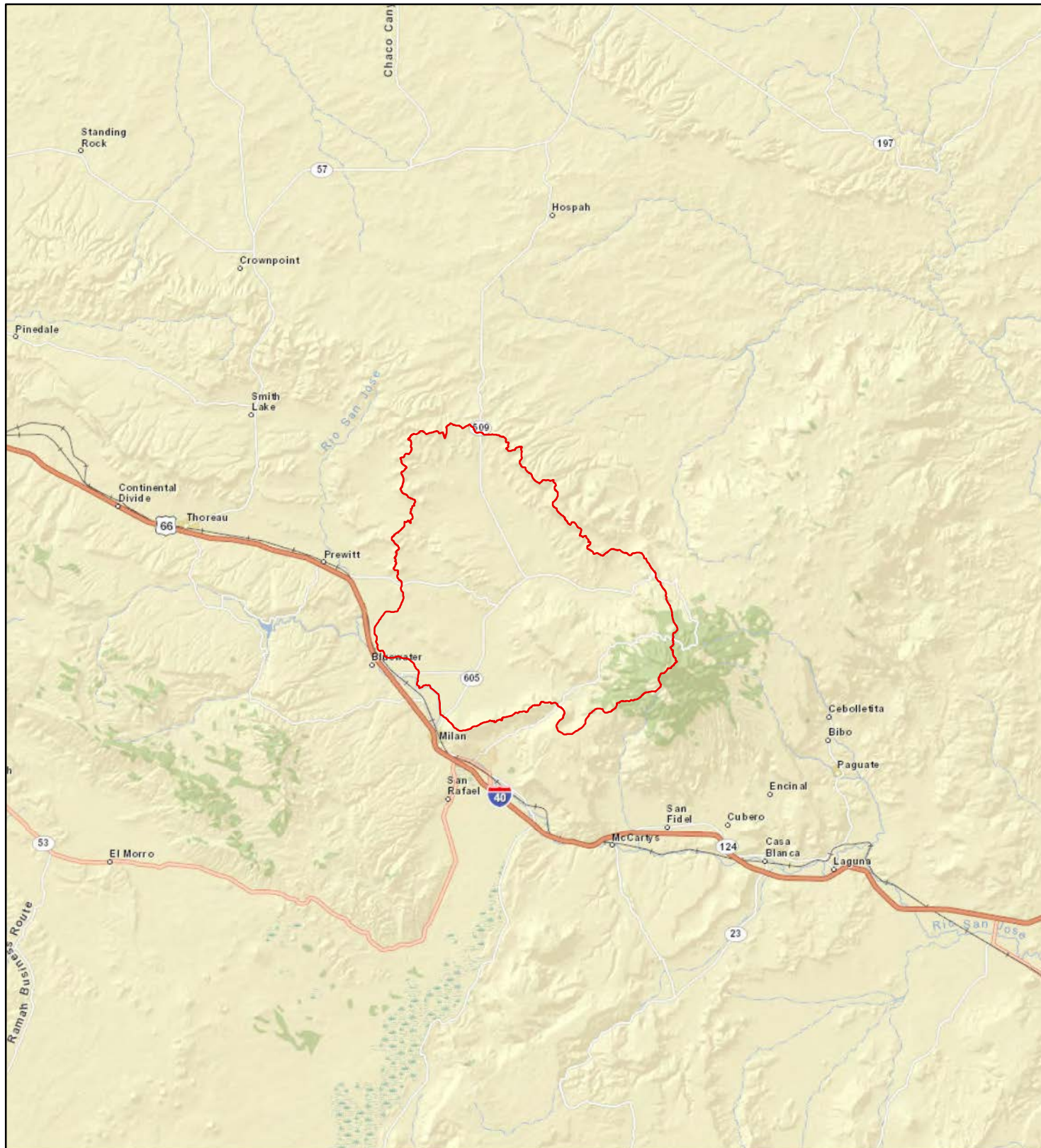
The EPA team will take photographs to document site conditions and activities as site work progresses. Initial conditions should be well documented by photographing features that define

the site-related contamination or special working conditions. Representative photographs should be taken of each type of site activity. The photographs should show typical operations and operating conditions as well as special situations and conditions that may arise during site activities. Site final conditions should also be documented as a record of how the site appeared at completion of the work.

Photographs will be taken using digital cameras capable of recording the date, time, and location. Each photograph will be recorded in the logbook with the location of the photographer, direction the photograph was taken, the subject of the photograph, and its significance (i.e., why the picture was taken).

5.2.3 Report Preparation

At the completion of the project, the EPA team will review and validate laboratory data and prepare a draft report of field activities and analytical results for EPA TM review. Draft deliverable documents will be uploaded to the EPA TeamLink Web site for EPA TM review and comment.



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LEGEND

San Mateo Drainage Basin

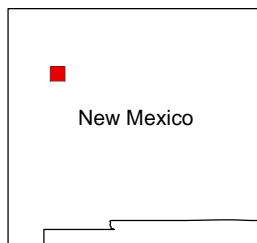


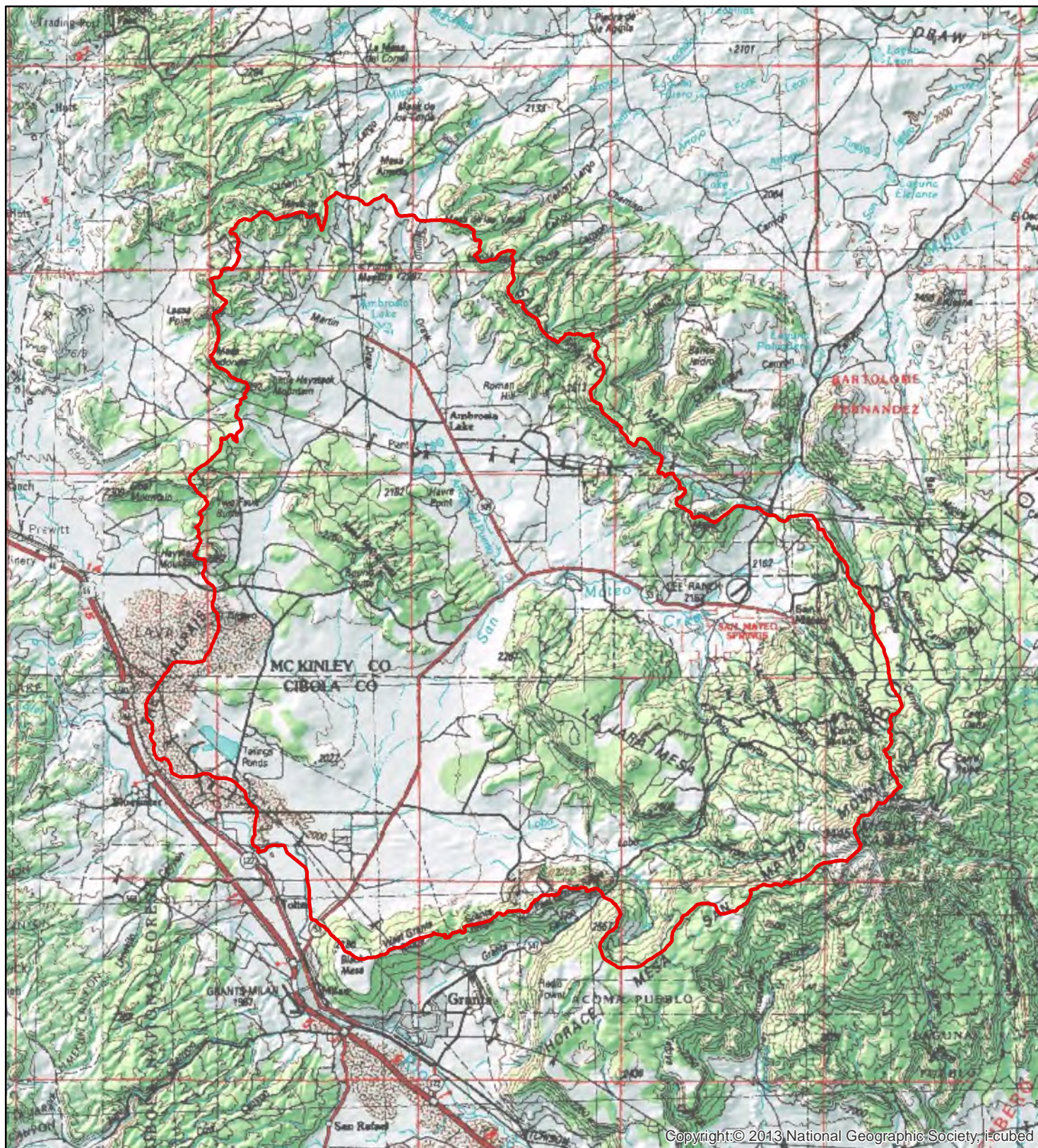
FIGURE 1-1
SITE LOCATION MAP
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

CERCLIS ID: NMN000606847
TDD NOS: 19/WESTON-042-13-001 & 35/WESTON-042-14-001
SOURCE: ESRI Street Map Online

DATE
OCTOBER, 2014

PROJECT NO
20406.012.019.0833.01 &
20406.012.035.0846.01

SCALE
AS SHOWN



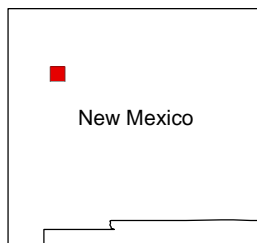
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Miles

LEGEND

San Mateo Drainage Basin



New Mexico



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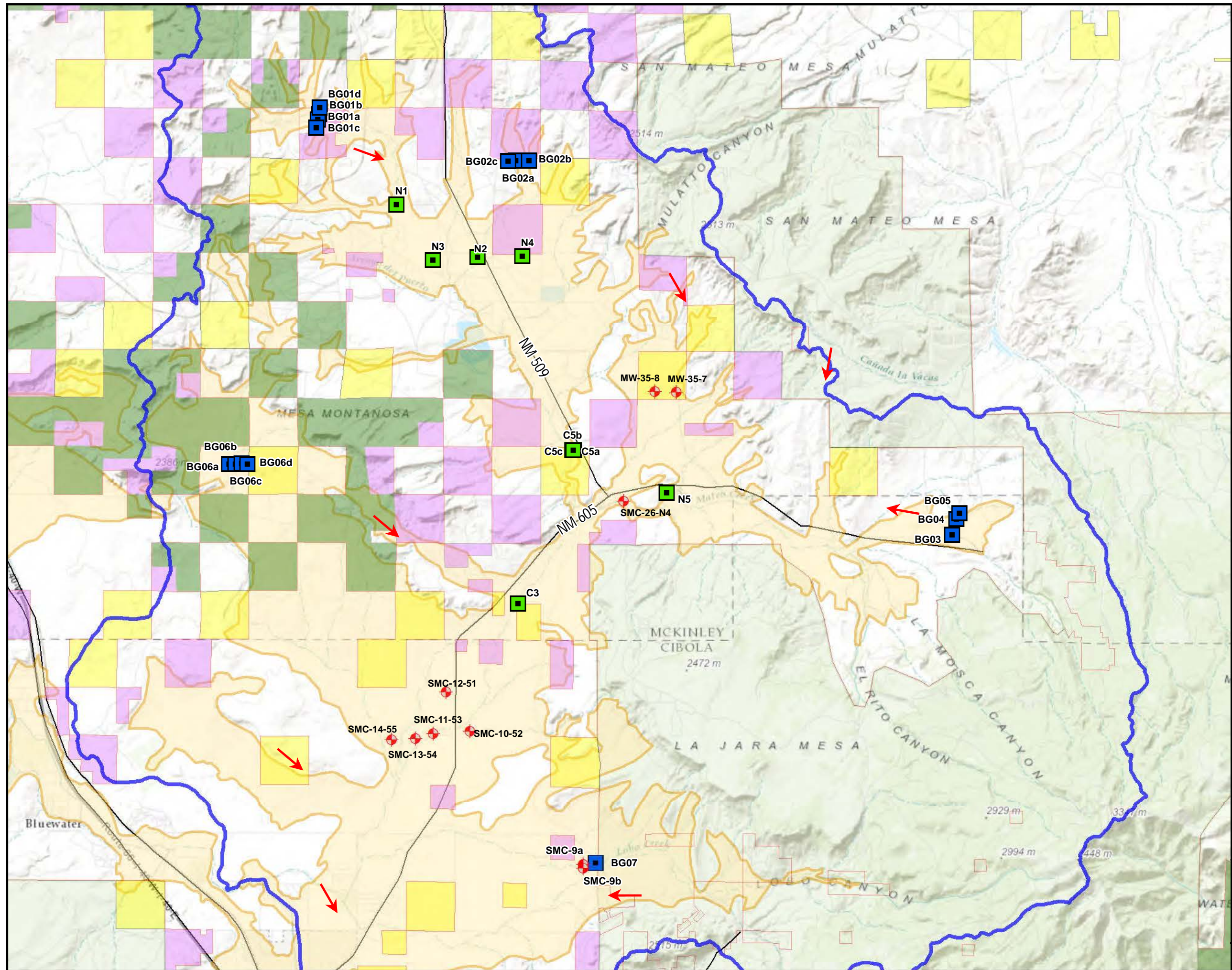
FIGURE 2-1
SITE AREA MAP
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE
OCTOBER, 2014

PROJECT NO
20406.012.019.0833.01 &
20406.012.035.0846.01

SCALE
AS SHOWN

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TDD NOS: 19/WESTON-042-13-001 & 35/WESTON-042-14-001
SOURCE: 2013 National Geographic Society

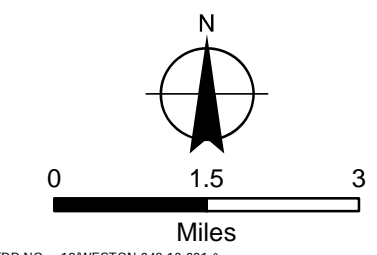


LEGEND

- Existing Monitoring Well Sample Locations
- Proposed Sampling Locations
- Proposed Background Sample Locations
- San Mateo Creek Basin

LANDOWNER STATUS

- Private Parcels
- BLM Parcels
- Tribal Parcels
- State Parcels
- Alluvium
- Inferred Groundwater Flow Direction



TDD NOS: 19/WESTON-042-13-001 &
35/WESTON-042-14-001
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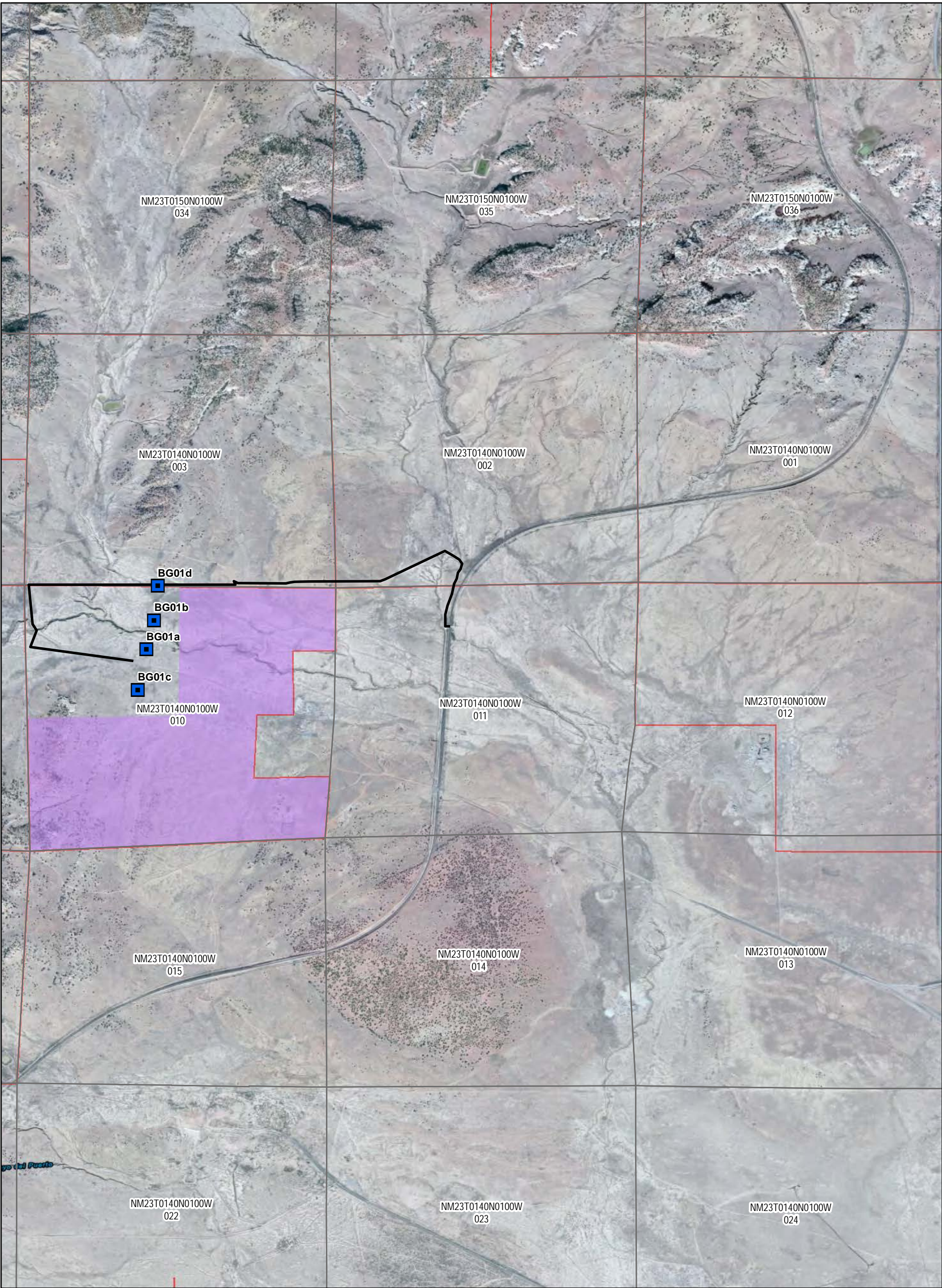
**US EPA REGION 6**

FIGURE 3-1
PROPOSED SAMPLE LOCATION MAP
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE	PROJECT NO	SCALE
OCT 2014	20406.012.019.0833.01 & 20406.012.035.0846.01	AS SHOWN



020004000

Feet

Proposed Background Sampling Locations

Proposed Route to Sample Location

Sections

Private Parcels

BLM Parcels

TDD NOs: 19/WESTON-042-13-001 & 35/WESTON-042-14-001
CERCLIS ID: NMN000606847
SOURCE: ESRI World Imagery

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Milan

Grants

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UNITED STATES

ENVIRONMENTAL PROTECTION AGENCY

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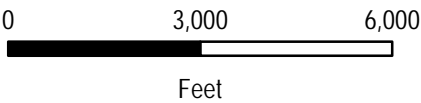
FIGURE 3-2
PROPOSED MONITORING WELL LOCATION MAP
BG-01
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE
OCTOBER, 2014

PROJECT NOs
20406.012.019.0833.01 &
20406.012.035.0846.01

SCALE
AS SHOWN

FILE: L:\20406_START3_R6\San Mateo Legacy Uranium Mines\GIS\Figure 3-2 BG01 Proposed Monitoring Well Location Map.mxd 11:56:40 AM 10/8/2014 bondp



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LEGEND

- Proposed Background Sampling Locations
- Proposed Route to Sample Location
- Sections
- LANDOWNER STATUS
- Private Parcels
- BLM Parcels

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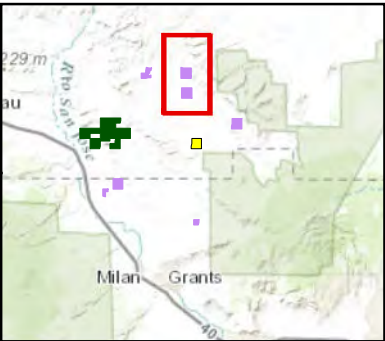
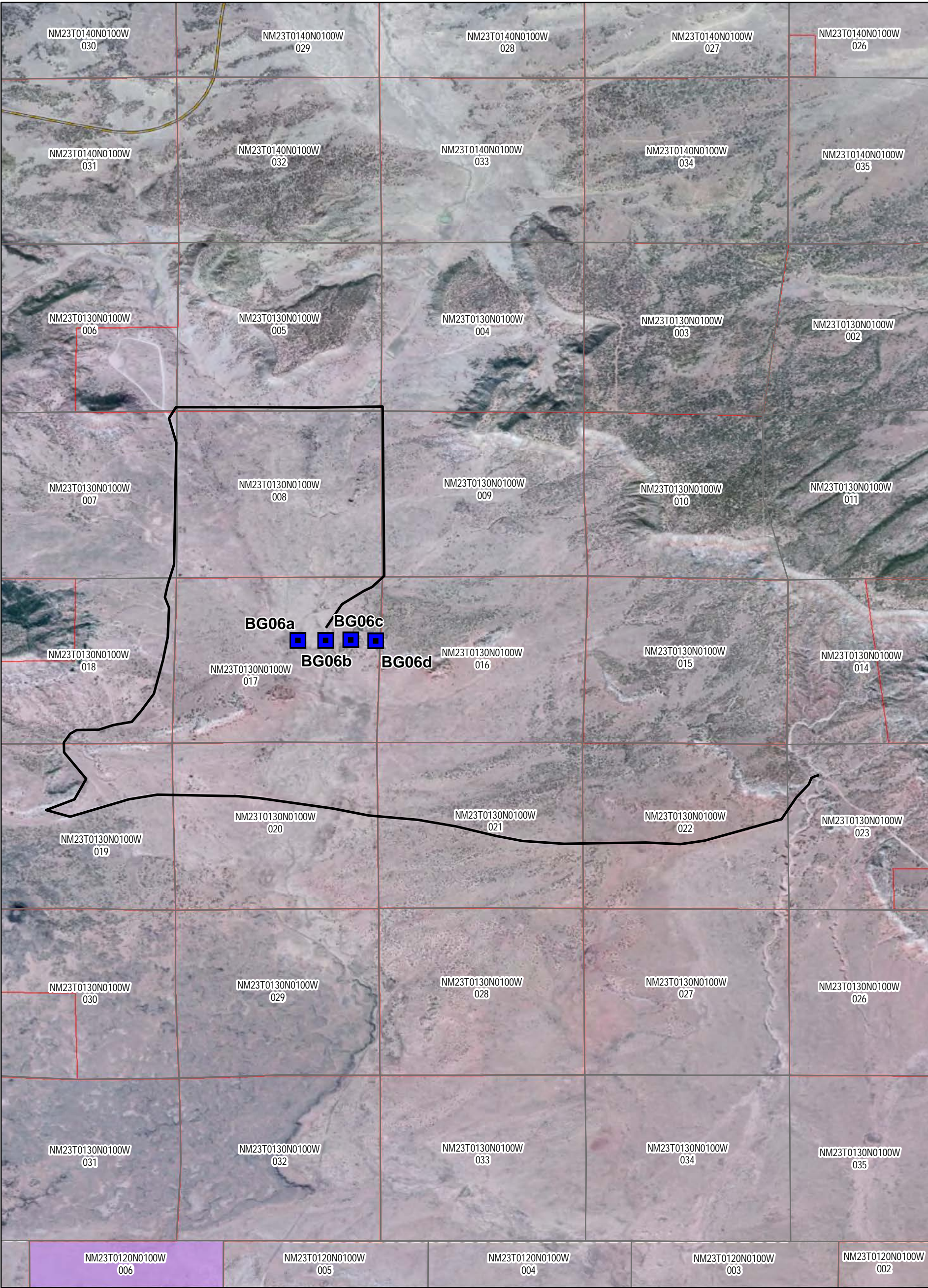


FIGURE 3-3
PROPOSED MONITORING WELL LOCATION MAP
BG-02
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE OCTOBER, 2014	PROJECT NOs 20406.012.019.0833.01 & 20406.012.035.0846.01	SCALE AS SHOWN
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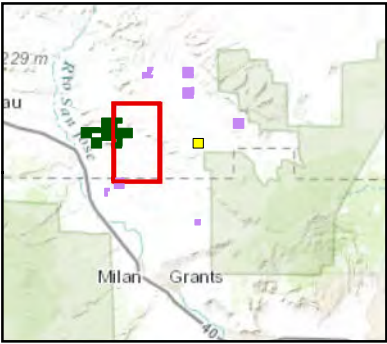
LEGEND

- Proposed Background Sampling Locations
- Proposed Route to Sample Location
- Sections

LANDOWNER STATUS

- Private Parcels
- BLM Parcels

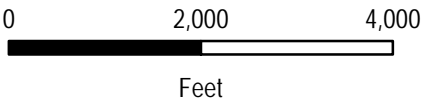
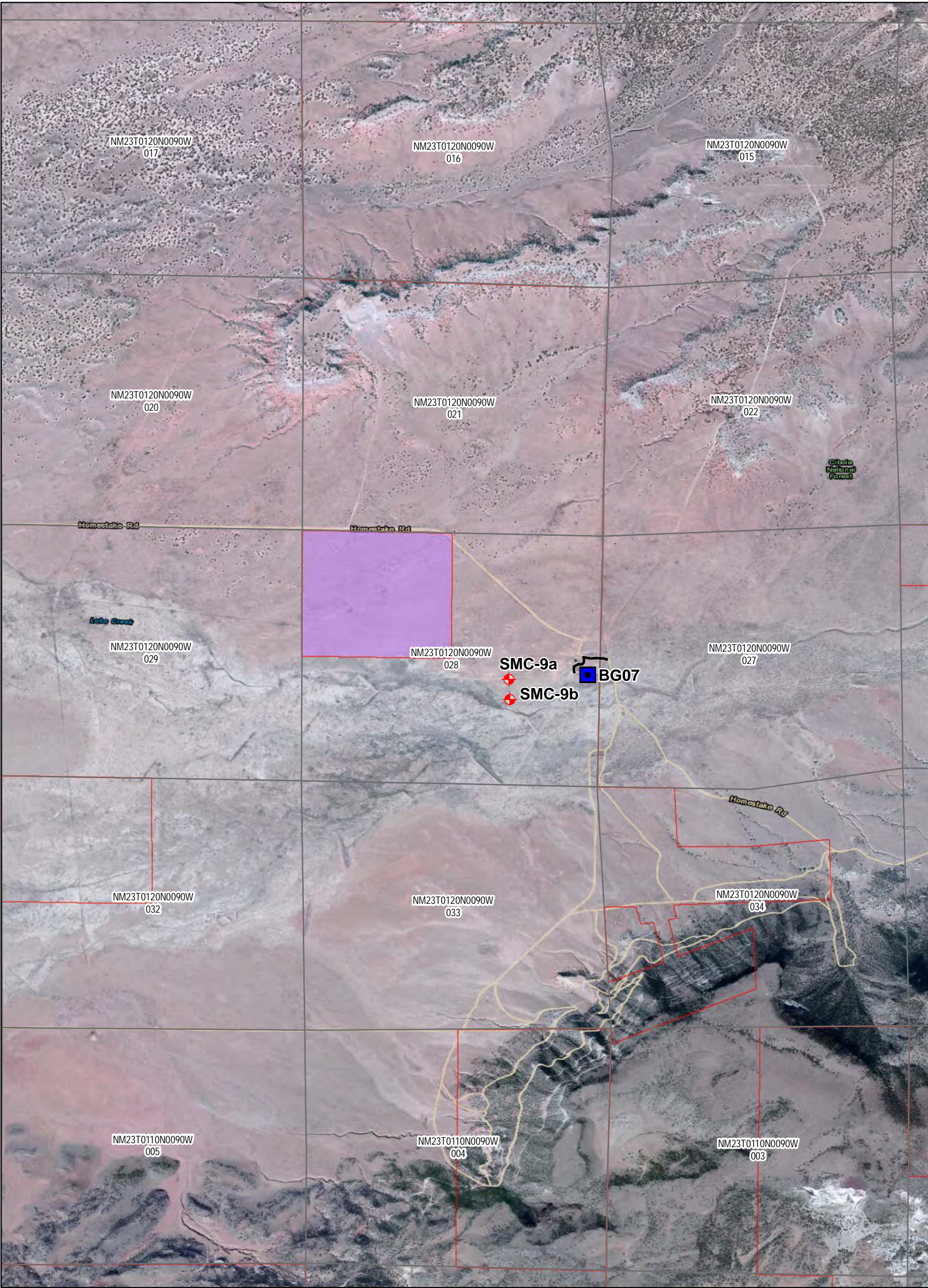
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SOURCE: ESRI World Imagery



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FIGURE 3-5
PROPOSED MONITORING WELL LOCATION MAP
BG-06
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

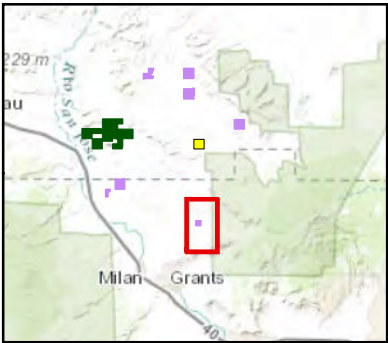
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LEGEND

- Proposed Background Sampling Location
- Existing Monitoring Well Locations
- Proposed Route to Sample Location
- Sections
- Private Parcels
- BLM Parcels
- LANDOWNER STATUS

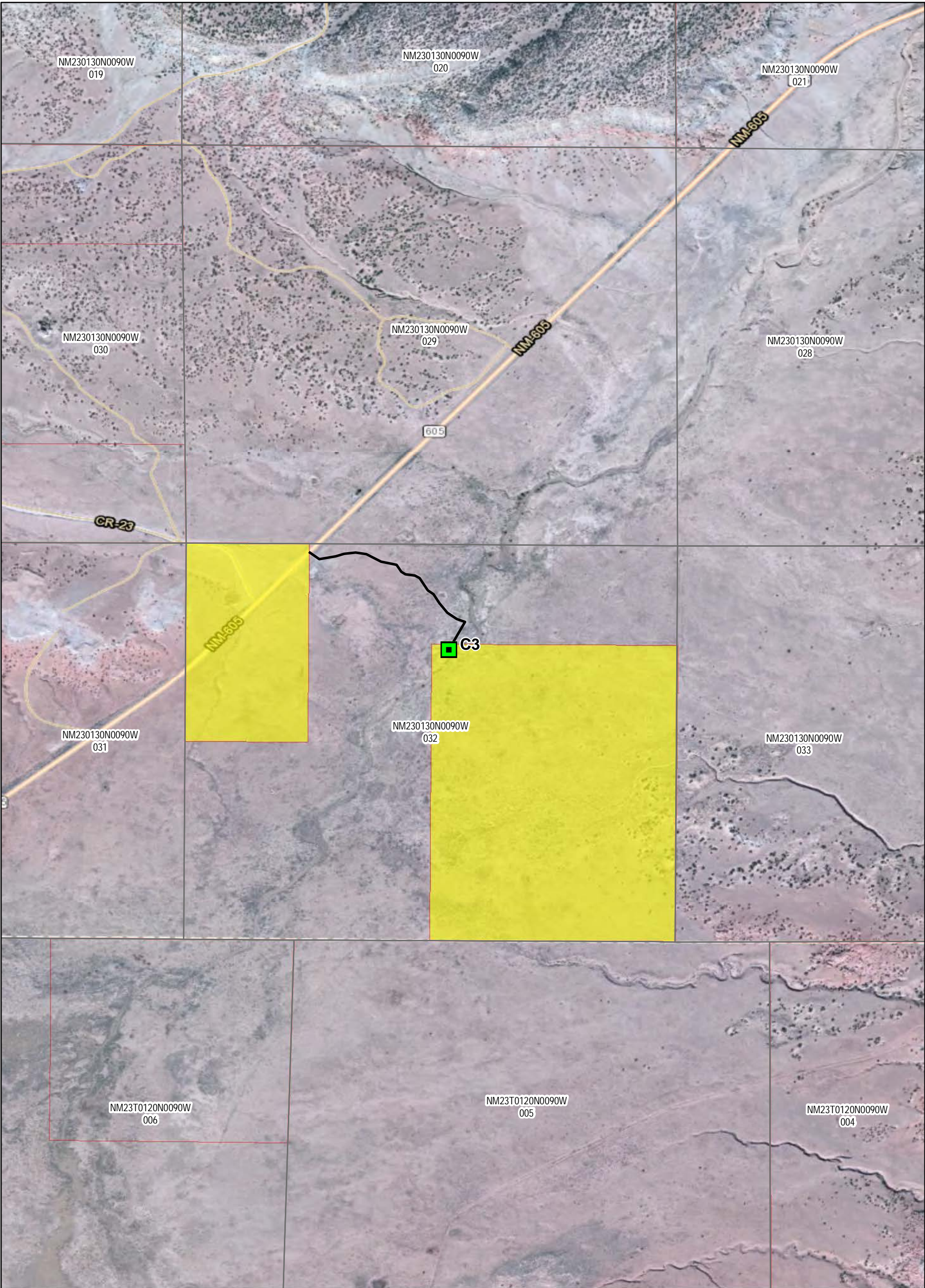
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SOURCE: ESRI World Imagery



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FIGURE 3-6
PROPOSED MONITORING WELL LOCATION MAP
BG-07
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

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LEGEND

- Proposed Sampling Locations
- Proposed Route to Sample Location
- Sections

LANDOWNER STATUS

- Private Parcels
- State Parcels

TDD NOs: 19/WESTON-042-13-001 & 35/WESTON-042-14-001
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SOURCE: 2013 National Geographic Society, i-cubed

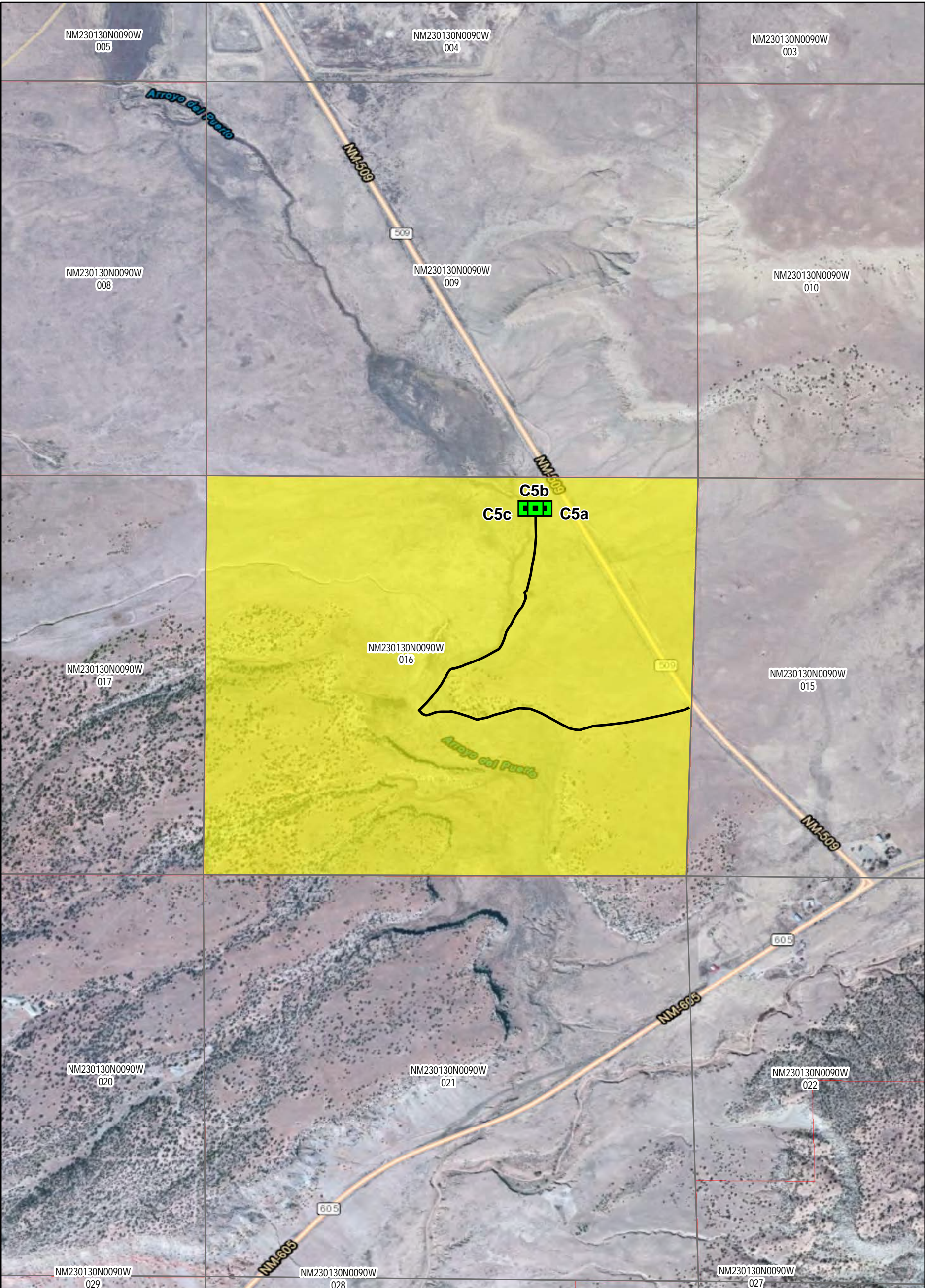
0 1,250 2,500

Feet

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FIGURE 3-7
PROPOSED MONITORING WELL LOCATION MAP
C3
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE OCTOBER, 2014	PROJECT NOs 20406.012.019.0833.01 & 20406.012.035.0846.01	SCALE AS SHOWN
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LEGEND

- Proposed Sampling Locations
- Proposed Route to Sample Location
- Sections

LANDOWNER STATUS

- Private Parcels
- State Parcels

TDD NOs: 19/WESTON-042-13-001 & 35/WESTON-042-14-001
CERCLIS ID: NMN000606847
SOURCE: 2013 National Geographic Society, i-cubed

0 1,250 2,500

Feet

US EPA REGION 6

FIGURE 3-8
PROPOSED MONITORING WELL LOCATION MAP
C5
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE OCTOBER, 2014	PROJECT NOs 20406.012.019.0833.01 & 20406.012.035.0846.01	SCALE AS SHOWN
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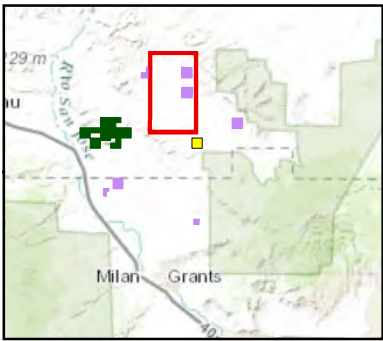
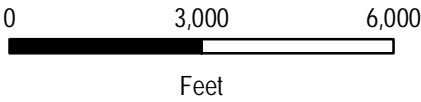
LEGEND

- Proposed Sample Locations
- Proposed Route to Sample Location
- Sections

LANDOWNER STATUS

- Private Parcels
- BLM Parcels

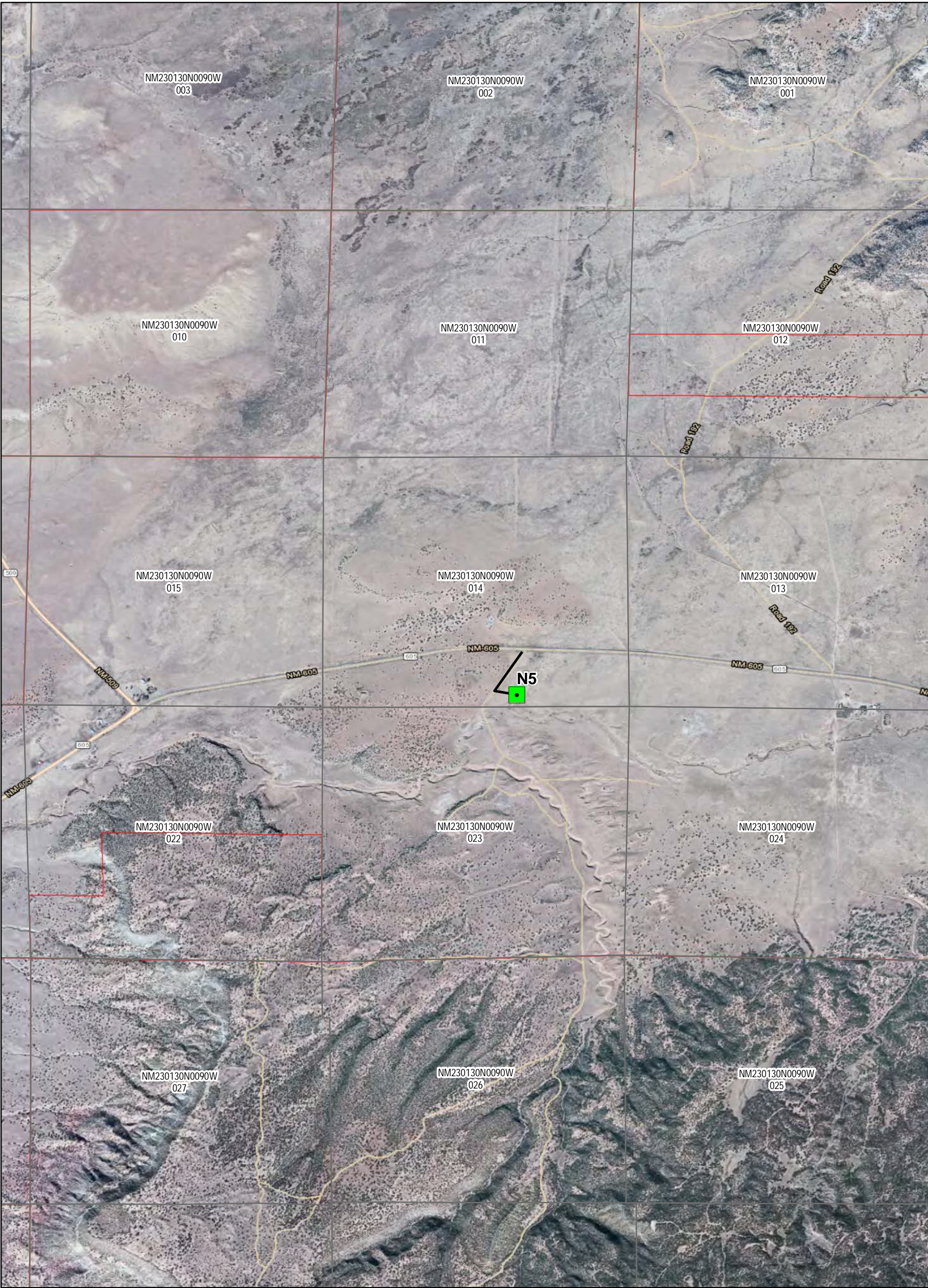
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35/WESTON-042-14-001
CERCLIS ID: NMN000606847
SOURCE: ESRI World Imagery



US EPA REGION 6

FIGURE 3-9
PROPOSED MONITORING WELL LOCATION MAP
N1, N2, N3, AND N4
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

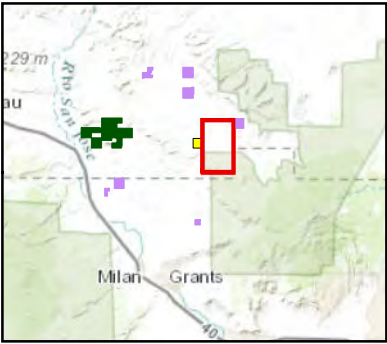
DATE OCTOBER, 2014	PROJECT NOS 20406.012.019.0833.01 & 20406.012.035.0846.01	SCALE AS SHOWN
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LEGEND

- Proposed Sample Locations
- Proposed Route to Sample Location
- Sections
- LANDOWNER STATUS
 - Private Parcels
 - BLM Parcels

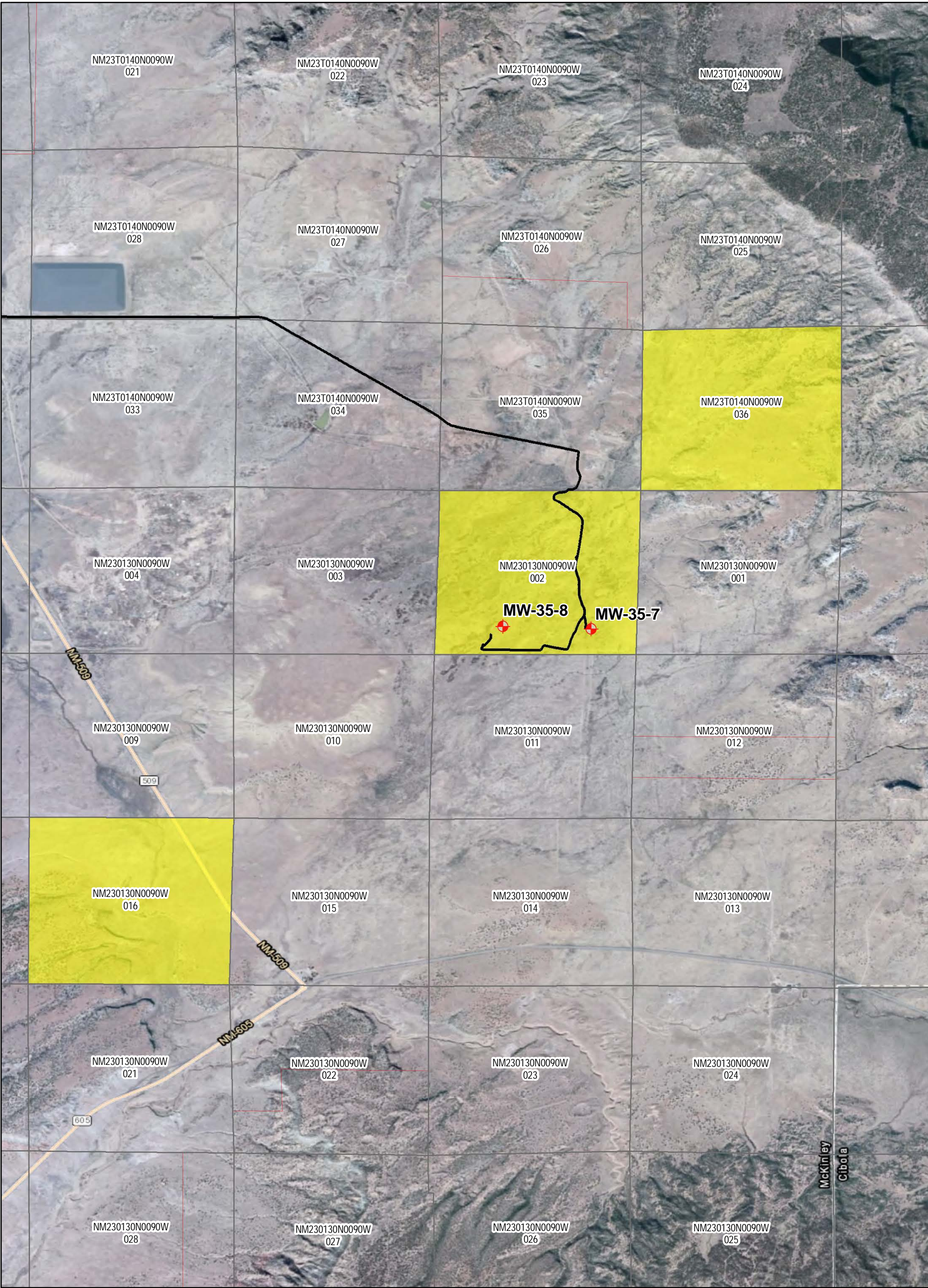
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CERCLIS ID: NMN000606847
SOURCE: ESRI World Imagery



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FIGURE 3-10
PROPOSED MONITORING WELL LOCATION MAP
N5
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE	PROJECT NOs	SCALE
OCTOBER, 2014	20406.012.019.0833.01 & 20406.012.035.0846.01	AS SHOWN



LEGEND

- Existing Monitoring Well Location
- Proposed Route to Sample Location
- Sections

LANDOWNER STATUS

- Private Parcels
- State Parcels

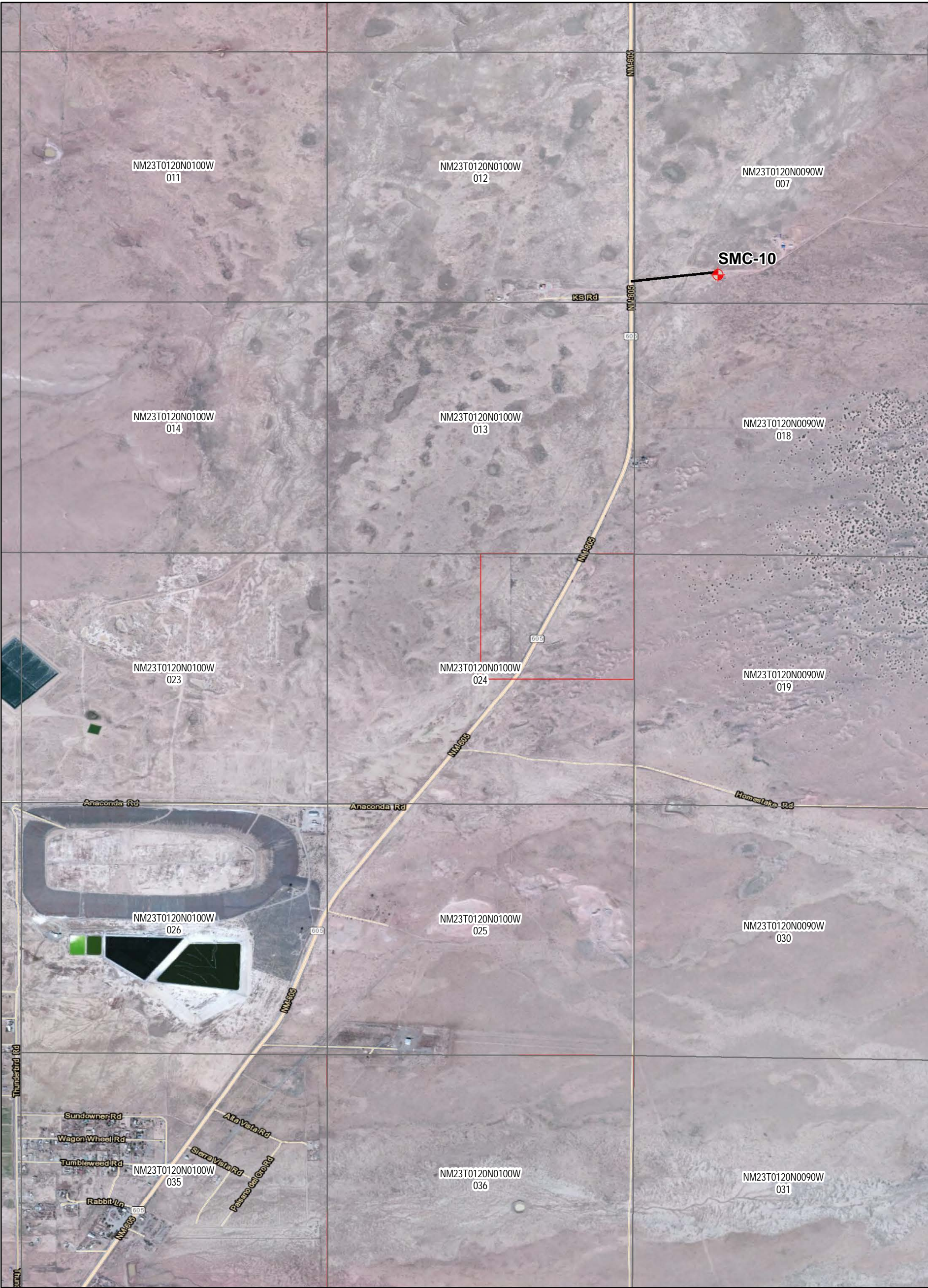
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35/WESTON-042-14-001
CERCLIS ID: NMN000606847
SOURCE: ESRI World Imagery



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FIGURE 3-11
MONITORING WELL LOCATION MAP
MW-35-7 AND MW-35-8
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE	PROJECT NOS	SCALE
OCTOBER, 2014	20406.012.019.0833.01 & 20406.012.035.0846.01	AS SHOWN



LEGEND

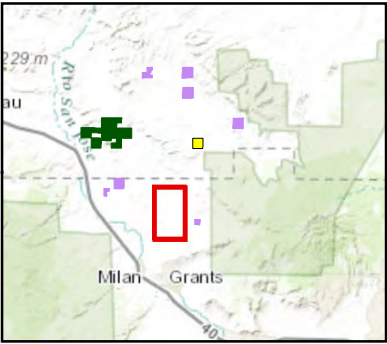
- Existing Monitoring Well Location
- Proposed Route to Sample Location

Sections

LANDOWNER STATUS

- Private Parcels
- BLM Parcels

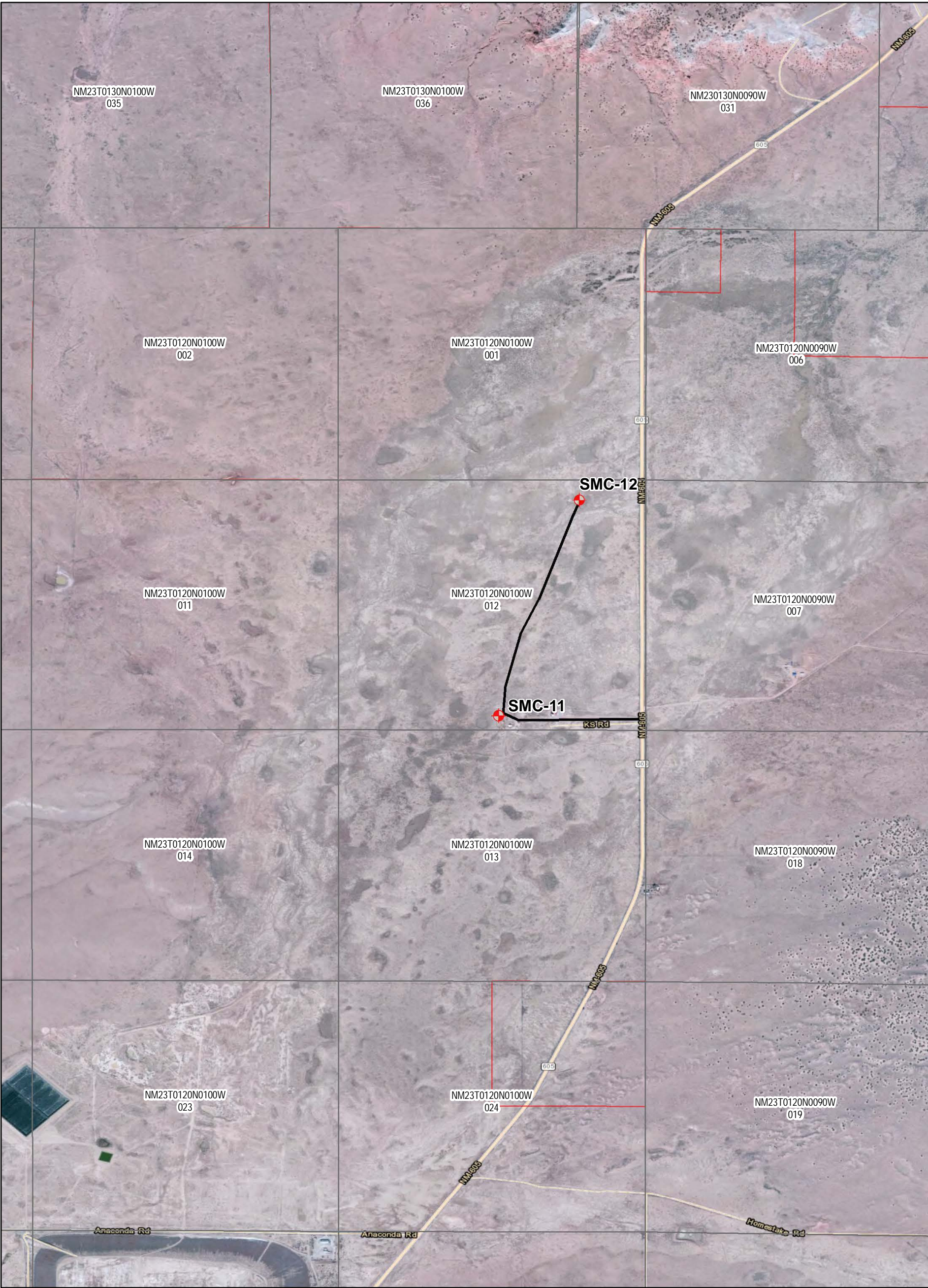
TDD NOs: 19/WESTON-042-13-001 &
35/WESTON-042-14-001
CERCLIS ID: NMN000606847
SOURCE: ESRI World Imagery



US EPA REGION 6

FIGURE 3-12
MONITORING WELL LOCATION MAP
SMC-10
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

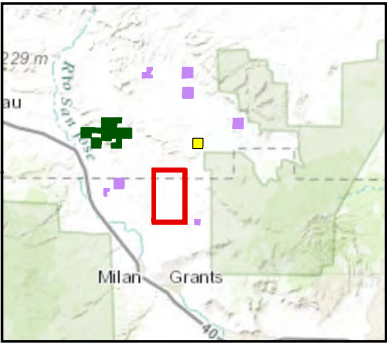
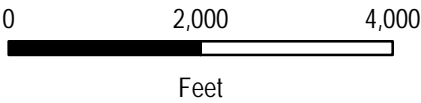
DATE	PROJECT NOs	SCALE
OCTOBER, 2014	20406.012.019.0833.01 & 20406.012.035.0846.01	AS SHOWN



LEGEND

- Existing Monitoring Well Location
- Proposed Route to Sample Location
- Sections
- LANDOWNER STATUS
 - Private Parcels
 - BLM Parcels

TDD NOs: 19/WESTON-042-13-001 &
35/WESTON-042-14-001
CERCLIS ID: NMN000606847
SOURCE: ESRI World Imagery



US EPA REGION 6

FIGURE 3-13
MONITORING WELL LOCATION MAP
SMC-11 AND SMC-12
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

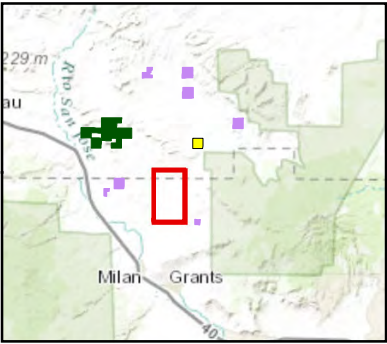
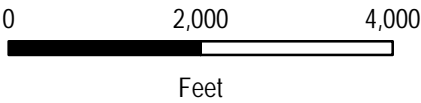
DATE OCTOBER, 2014	PROJECT NOs 20406.012.019.0833.01 & 20406.012.035.0846.01	SCALE AS SHOWN
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LEGEND

- Existing Monitoring Well Location
- Proposed Route to Sample Location
- Sections
- LANDOWNER STATUS
 - Private Parcels
 - BLM Parcels

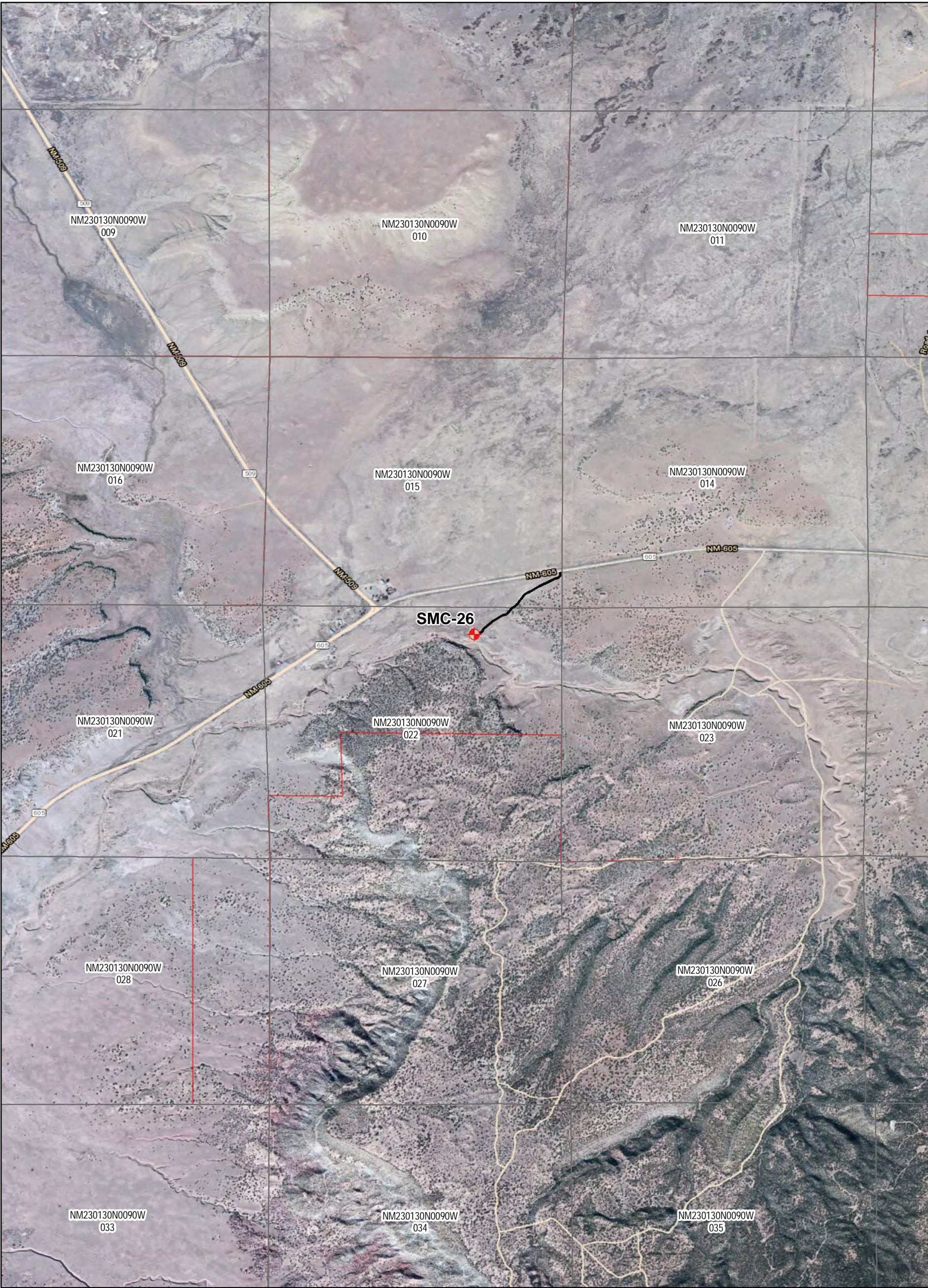
TDD NOs: 19/WESTON-042-13-001 & 35/WESTON-042-14-001
CERCLIS ID: NMN000606847
SOURCE: ESRI World Imagery



US EPA REGION 6

FIGURE 3-14
MONITORING WELL LOCATION MAP
SMC-13 AND SMC-14
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE OCTOBER, 2014	PROJECT Nos 20406.012.019.0833.01 & 20406.012.035.0846.01	SCALE AS SHOWN
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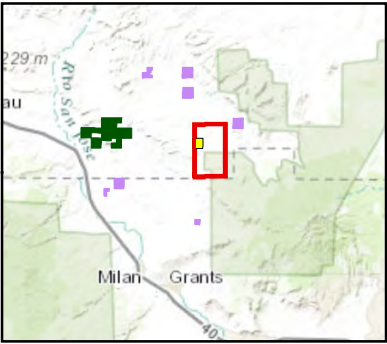
LEGEND

- Existing Monitoring Well Location
- Proposed Route to Sample Location

Sections

- LANDOWNER STATUS
- Private Parcels
 - BLM Parcels

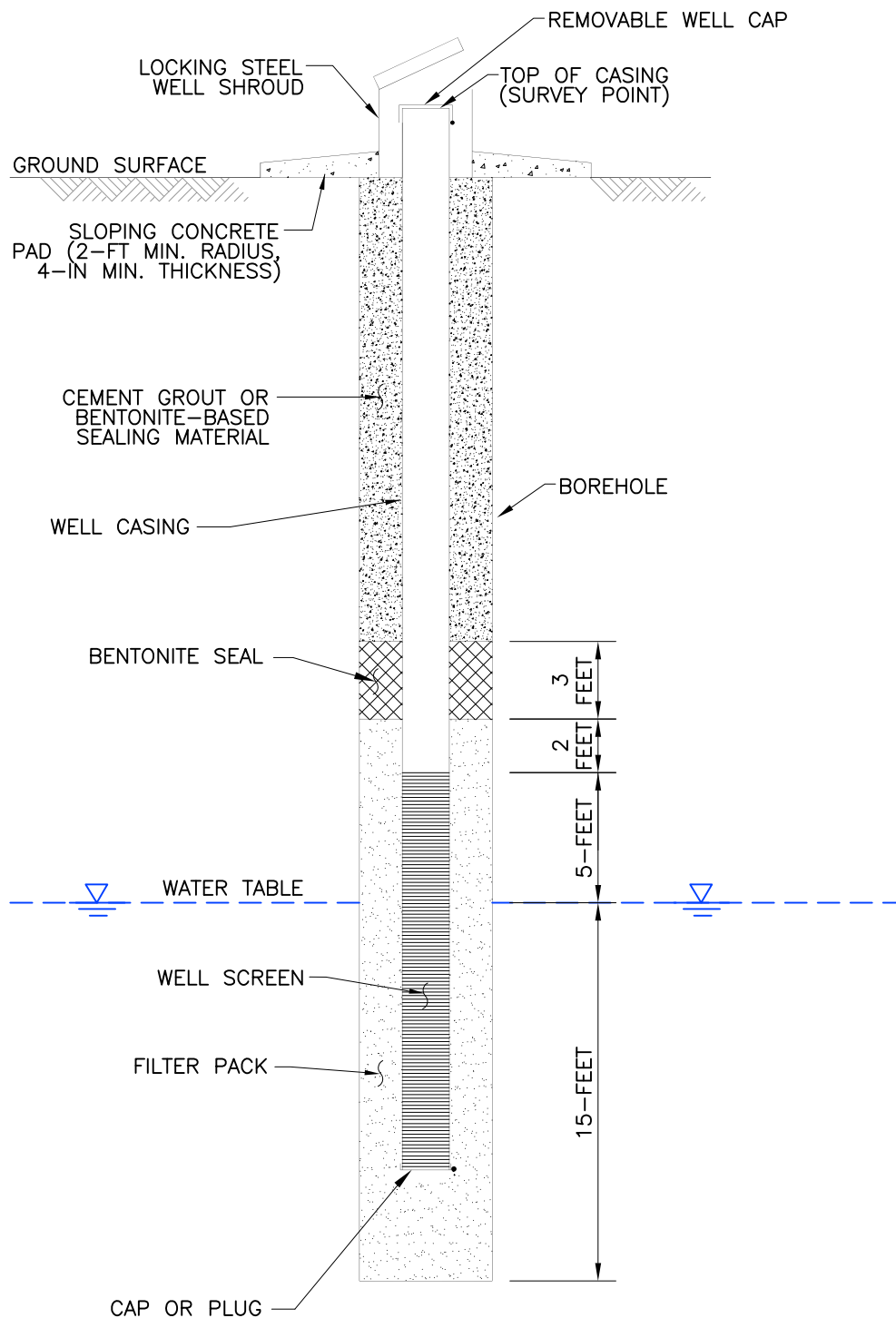
TDD NOS: 19/WESTON-042-13-001 &
35/WESTON-042-14-001
CERCLIS ID: NMN000606847
SOURCE: ESRI World Imagery



US EPA REGION 6

FIGURE 3-15
MONITORING WELL LOCATION MAP
SMC-26
SAN MATEO CREEK BASIN
NEAR GRANTS
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE	PROJECT NOS	SCALE
OCTOBER, 2014	20406.012.019.0833.01 & 20406.012.035.0846.01	AS SHOWN



US EPA REGION 6

FIGURE 3-16 **MONITORING WELL SCHEMATIC**

SAN MATEO CREEK BASIN
NEAR GRANTS

CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

SOURCE: NEW MEXICO ENVIRONMENTAL DEPARTMENT
MONITORING WELL GUIDELINES REV. 1.1, MARCH 2011.
CERCLIS No.: NMN000606847
TDD Nos.: 19/WESTON-042-13-001 AND 35/WESTON-042-14-001

DATE:
SEP 2014

W.O. #
20406.012.019.0833.01
20406.012.035.0846.01

SCALE:
NOT TO SCALE

APPENDIX A
SITE-SPECIFIC DATA QUALITY OBJECTIVE

**SITE-SPECIFIC DATA QUALITY OBJECTIVE
SAN MATEO CREEK BASIN URANIUM LEGACY SITE
NEAR GRANTS, CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO
MEDIA OF CONCERN: GROUNDWATER**

STEP 1. STATE THE PROBLEM	
Historical surface and underground mining operations contributed waste (uranium and other metals/radionuclides) to natural surface drainage systems and alluvial groundwater within the San Mateo Creek Basin, thus representing a threat to human health and the environment.	
STEP 2. IDENTIFY THE DECISION	
Groundwater samples will be collected from up to 14 newly installed monitor wells and 10 existing wells to evaluate groundwater quality conditions.	
IDENTIFY THE ALTERNATIVE ACTIONS THAT MAY BE TAKEN BASED ON THE DECISIONS.	<ul style="list-style-type: none"> ▪ If concentrations of chemicals-of-concern (CoCs) in the groundwater samples are above federal maximum contaminant levels (MCLs), then a probable release to groundwater has been established. ▪ If concentrations of CoCs in groundwater samples are below federal MCLs, then a probable release has not been established. ▪ General water chemistry data will be used to update the hydrologic model of the site.
STEP 3. IDENTIFY INPUTS TO THE DECISION	
IDENTIFY THE INFORMATIONAL INPUTS NEEDED TO RESOLVE A DECISION.	<p>Review the following:</p> <ul style="list-style-type: none"> ▪ Historical site operations contributing to contamination. ▪ Historical groundwater and surface water data collected at the site. ▪ New groundwater and surface water sampling during this ESI. ▪ Groundwater elevations.
IDENTIFY THE SOURCES FOR EACH INFORMATIONAL INPUT AND LIST THE INPUTS THAT ARE OBTAINED THROUGH ENVIRONMENTAL MEASUREMENTS.	<p>Review the following:</p> <ul style="list-style-type: none"> ▪ New and existing groundwater monitoring well locations as shown in Figure 3-1. ▪ Groundwater and surface water inorganic chemical analyses as noted in Table 4-1 of the QASP. ▪ Radionuclide analysis as noted in Table 4-1 of the QASP.

**SITE-SPECIFIC DATA QUALITY OBJECTIVE
SAN MATEO CREEK BASIN URANIUM LEGACY SITE
NEAR GRANTS, CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO
MEDIA OF CONCERN: GROUNDWATER (CONTINUED)**

STEP 3. IDENTIFY INPUTS TO THE DECISION (CONTINUED)	
BASIS FOR THE CONTAMINANT-SPECIFIC ACTION LEVELS.	The concentration of a CoC in groundwater samples must be greater than the MCLs.
IDENTIFY POTENTIAL SAMPLING TECHNIQUES AND APPROPRIATE ANALYTICAL METHODS.	Groundwater samples will be collected in accordance with the following: <ul style="list-style-type: none"> Standard Groundwater Sampling Procedures and Weston Groundwater Sampling SOPs. Inorganic chemical analyses as noted in Table 4-1 of the QASP. Radionuclide analysis as noted in Table 4-1 of the QASP.
STEP 4. DEFINE THE BOUNDARIES OF THE STUDY	
DEFINE THE DOMAIN OR GEOGRAPHIC AREA WITHIN WHICH ALL DECISIONS MUST APPLY.	Selected groundwater monitoring wells and existing monitoring wells located within the San Mateo Creek Basin.
SPECIFY THE CHARACTERISTICS THAT DEFINE THE POPULATION OF INTEREST.	Groundwater includes the alluvial system within the San Mateo Drainage Basin, which is unconfined and has distinct water chemistry.
DEFINE THE SCALE OF DECISION MAKING.	Results of groundwater sampling will be used to evaluate groundwater quality conditions.
DETERMINE THE TIME FRAME TO WHICH THE DATA APPLY.	The data will apply until the site media, represented by groundwater samples, receives appropriate remedial actions.
DETERMINE WHEN TO COLLECT DATA.	Samples will be collected during the EPA team field effort scheduled for late October 2014.
IDENTIFY PRACTICAL CONSTRAINTS ON DATA COLLECTION.	<ul style="list-style-type: none"> Inclement weather. Access not attainable. Wells destroyed or inoperable. Lack of groundwater at proposed locations. Complex geochemistry.
STEP 5. DEVELOP A DECISION RULE	
SPECIFY THE PARAMETER THAT CHARACTERIZES THE POPULATION OF INTEREST.	Detection of CoCs in the water samples by analytical testing above EPA MCLs.

**SITE-SPECIFIC DATA QUALITY OBJECTIVE
SAN MATEO CREEK BASIN URANIUM LEGACY SITE
NEAR GRANTS, CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO
MEDIA OF CONCERN: GROUNDWATER (CONTINUED)**

STEP 5. DEVELOP A DECISION RULE (CONTINUED)	
SPECIFY THE ACTION LEVEL FOR THE DECISION.	<ul style="list-style-type: none"> ▪ If CoCs are detected in groundwater above MCLs, then an observed release has been established. ▪ If CoCs in the groundwater samples are not above MCLs, then an observed release has not been established.
STEP 6. SPECIFY LIMITS ON DECISION ERRORS	
DEVELOP A DECISION RULE.	If site groundwater samples have CoCs that are detected at elevations above MCLs, then an observed release to the groundwater pathway has been established.
DETERMINE THE POSSIBLE RANGE OF THE PARAMETER OF INTEREST.	Contaminant concentrations may range from non-detect to more than the MCL.
DEFINE BOTH TYPES OF DECISION ERRORS AND IDENTIFY THE POTENTIAL CONSEQUENCES OF EACH.	<p><u>Type I Error:</u> Deciding that the specified area represented by the groundwater sample does not exceed the specified assessment level when, in truth, the concentration of the contaminant exceeds its specified assessment level. The consequence of this decision error is that remedial efforts in the watershed may not be undertaken, possibly endangering human health and the environment. This decision error is more severe.</p> <p><u>Type II Error:</u> Deciding that the specified area represented by the groundwater sample does exceed the specified assessment level when, in truth, it does not. The consequences of this decision error are that remediation of the watershed will continue and unnecessary costs will be incurred.</p>
ESTABLISH THE TRUE STATE OF NATURE FOR EACH DECISION RULE.	<p>The true state of nature when the groundwater is decided to be below the specified assessment levels when in fact, it is not below the specified assessment levels, is that the watershed does need remedial action.</p> <p>The true state of nature when the groundwater is decided to be above the specified assessment levels when in fact, it is not above the specified assessment levels, is that the watershed does not need remedial action.</p>

**SITE-SPECIFIC DATA QUALITY OBJECTIVE
SAN MATEO CREEK BASIN URANIUM LEGACY SITE
NEAR GRANTS, CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO
MEDIA OF CONCERN: GROUNDWATER (CONTINUED)**

STEP 6. SPECIFY LIMITS ON DECISION ERRORS (CONTINUED)	
DEFINE THE TRUE STATE OF NATURE FOR THE MORE SEVERE DECISION ERROR AS THE BASELINE CONDITION OR THE NULL HYPOTHESIS (H_0) AND DEFINE THE TRUE STATE FOR THE LESS SEVERE DECISION ERROR AS THE ALTERNATIVE HYPOTHESIS (H_a).	H_0 : The water represented by the sample is above the specified MCL. H_a : The water represented by the sample is below the specified MCL.
ASSIGN THE TERMS "FALSE POSITIVE" AND "FALSE NEGATIVE" TO THE PROPER DECISION ERRORS.	<ul style="list-style-type: none"> ▪ False Positive Error = Type I ▪ False Negative Error = Type II
ASSIGN PROBABILITY VALUES TO POINTS ABOVE AND BELOW THE ACTION LEVEL THAT REFLECT THE ACCEPTABLE PROBABILITY FOR THE OCCURRENCES OF DECISION ERRORS.	To be assigned based on discussions with EPA TM.
STEP 7. OPTIMIZE THE DESIGN	
REVIEW THE DQOs.	Due to insufficient historical data, determination of the standard deviation was not possible. Therefore, sample size calculation using the traditional statistical formula may not be the optimal design. To select the optimal sampling program that satisfies the DQOs and is the most resource effective, other elements were considered.
DEVELOP GENERAL SAMPLING AND ANALYSIS DESIGN. Up to 24 groundwater samples will be collected from existing monitoring wells and newly installed monitoring wells to determine alluvial groundwater conditions within the San Mateo Drainage Basin.	

APPENDIX B

EPA GUIDANCE FOR LOW-FLOW (MINIMAL DRAWDOWN) GROUNDWATER SAMPLING PROCEDURES



Ground Water Issue

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls¹ and Michael J. Barcelona²

Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

For further information contact: Robert Puls, 405-436-8543, Subsurface Remediation and Protection Division, NRMRL, Ada, Oklahoma.

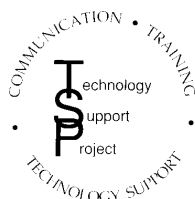
I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing

units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic *units*. With time it became apparent that conventional water supply generalizations of *homogeneity* did not adequately represent field data regarding pollution of these subsurface resources. The important role of *heterogeneity* became increasingly clear not only in geologic terms, but also in terms of complex physical,

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Office of Solid Waste and Emergency
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Walter W. Kovalick, Jr., Ph.D.
Director

chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and *aquifers* or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third *phase* as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueudre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria.

These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the *total* mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias *naturally* suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic *push* technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling

objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metal-loids) or organic compounds.

II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

- 1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;
- 2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and
- 3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

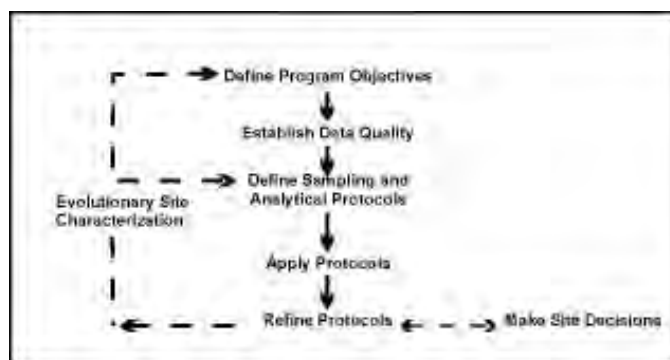


Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these *over-sampling* concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few

feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design

In most cases *well-point* diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that *short* (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. *Short*, of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than *direct-push* technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality *recovery* period.

III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-

flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxida-

tion-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the *mobile* load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:

- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action*.

IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to

sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g., pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:

- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of *low* flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause *significant* drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other *grab* type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of *stagnant* water in the casing and the *dynamic* water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over any other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a *fix* for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally *dissolved* [i.e., samples filtered with 0.45 µm filters]) concentrations of major ions and trace metals, 0.1 µm filters are recommended although 0.45 µm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO₂ composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 µm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality

indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, $\pm 3\%$ for conductivity, ± 10 mv for redox potential, and $\pm 10\%$ for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+} , CH_4 , $\text{H}_2\text{S}/\text{HS}^-$; alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-846 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or

introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:

- (1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.
- (2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.
- (3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of

the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. Low-Permeability Formations (<0.1 L/min recharge)

1. Low-Flow Purging and Sampling with Pumps

- a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.
- b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop -- A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

VII. Notice

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Project _____ **Site** _____ **Well No.** _____ **Date** _____
Well Depth _____ **Screen Length** _____ **Well Diameter** _____ **Casing Type** _____
Sampling Device _____ **Tubing type** _____ **Water Level** _____
Measuring Point _____ **Other Infor** _____

Sampling Personnel _____

[illegible]

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $\text{Vol}_{\text{cyl}} = \pi r^2 h$, $\text{Vol}_{\text{sphere}} = 4/3 \pi r^3$

Project _____ Site _____ Well No. _____ Date _____

Well Depth _____ Screen Length _____ Well Diameter _____ Casing Type _____

Sampling Device _____ Tubing type _____ Water Level _____

Measuring Point _____ Other Infor _____

Sampling Personnel _____

[illegible]

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3 \pi r^3$

APPENDIX C

STANDARD OPERATING PROCEDURES (SOPs)

SOP	0110.04				
GROUP	Database Management System				
SUB-GROUP	Data Collection and Acquisition				
TITLE	On-Site Sample Nomenclature - On-Site Sampling Activities				
DATE	11/19/2001	FILE	0110-04.DOC	PAGE	1 of 1

INTRODUCTION

The following Standard Operating Procedure (SOP) presents the remediation sample nomenclature for analytical samples. The sample nomenclature is based upon specific code requirements for compatibility with the WESTON On-Line system

PROCEDURE

Sampling Stations.

Station Type	Template
Soil Stockpile	SS##
Monitoring Well	MW##
Surface Water Pond	POND##
Air Sampler	AIR##

Sample Nomenclature.

Sample Type	Template	Example
Soil Composite Sample	Stockpile - Type - QC - Sequence	SS01-CO-N-1
Surface Water Sample	Surface Water Pond-Type-QC-Sequence	POND03-CO-N-1
Groundwater Sample	Monitoring Well-Type-QC-Sequence	MW12-CO-N-1
Ambient Air Sample	Air Sampler-Sample Type-QC Type-Sequence	AIR01-TI-N-1

Note: Sequence is a numeric counter to make Sample ID unique if more than one sample is collected.

Sample Types.

Sample Type Description	Code
Composite	CO
Grab	G
Product – DNAPL	PD
Product – LNAPL	PL
Split	SP
Time Integrated	TI

QA/QC Types.

QA/QC Type Description	Code
Normal	N
Duplicate	D
Field Blank	FB
Rinse Blank	RB
Trip Blank	TB

SOP	1001.01				
GROUP	Sampling Procedures				
SUB-GROUP	Soil Sampling Procedures				
TITLE	Surface Soil Sampling				
DATE	11/19/2001	FILE	1001-01.DOC	PAGE	1 of 3

INTRODUCTION

The following Standard Operating Procedure (SOP) is to describe the procedures for collecting representative soil samples. Analysis of soil samples may determine whether concentrations of specific soil pollutants exceed established action levels, or if the concentrations of soil pollutants present a risk to public health, welfare, or the environment. This SOP is similar to SOP Number 1001.03 for collecting near surface soil samples with a hand auger.

PROCEDURE

Surface soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed versus undisturbed), and the type of soil. Near-surface soils may be easily sampled using a spade, trowel, or hand scoop.

Sample Preservation

Cooling to $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$, supplemented by a minimal holding time, is suggested.

Interferences and Potential Problems

There are two primary interferences or potential problems associated with soil sampling: cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated (disposable) sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results. Homogenization may also affect sample representativeness where the analytical requirements include volatile organic compounds.

Equipment or Apparatus

The equipment used for sampling may be selected from the following list, as appropriate:

- Tape measure
- Survey stakes or flags
- Stainless steel, plastic, or other appropriate homogenization bucket or bowl
- Ziploc plastic bags
- Logbook
- Labels
- Chain-of-custody forms and seals
- Coolers
- Ice
- Decontamination supplies and equipment
- Canvas or plastic sheet
- Spatulas/spades/shovels
- Scoops

SOP	1001.01				
GROUP	Sampling Procedures				
SUB-GROUP	Soil Sampling Procedures				
TITLE	Surface Soil Sampling				
DATE	11/19/2001	FILE	1001-01.DOC	PAGE	2 of 3

- Plastic or stainless steel spoons
- Trowel

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and what equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment from the list above.
3. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.
4. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
5. Decontaminate or preclean equipment, and ensure that it is in working order.
6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner or other responsible party prior to soil sampling.
7. Evaluate safety concerns associated with sampling that may require use of personal protective equipment and/or air monitoring.

Surface Soil Sample Collection

Collect samples from the near-surface soil with tools such as spades, shovels, and scoops. Surface material can be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Avoid the use of devices plated with chrome or other target analyte materials.

The following procedures should be followed when collecting surface soil samples:

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.
2. Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area which came in contact with the spade.
3. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or if composite samples are to be collected, place a sample from another sampling interval into the

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homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled container(s) and secure the cap(s) tightly.

4. Fill hole created through sampling with unused material or other appropriate backfill material (sand).
5. Record applicable information into field log book or appropriate forms as documentation of sampling.

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GROUP	Sampling Procedures				
SUB-GROUP	Soil Sampling Procedures				
TITLE	Subsurface Soil Sampling - Drilling				
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INTRODUCTION

The following Standard Operating Procedure (SOP) is to describe the procedures for collecting representative soil samples. Analysis of soil samples may determine whether concentrations of specific soil pollutants exceed established action levels, or if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

PROCEDURE

Soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed versus undisturbed), and the type of soil. Sampling at depth may be performed using a hand auger, a trier, a split-spoon, or, if required, a backhoe.

Sample Preservation

Refrigeration to 4°C, supplemented by a minimal holding time, is suggested.

Interferences and Potential Problems

There are two primary interferences or potential problems associated with soil sampling: cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

Equipment or Apparatus

- Compass
- Tape measure
- Survey stakes or flags
- Stainless steel, plastic, or other appropriate homogenization bucket or bowl
- Ziploc plastic bags
- Logbook
- Labels
- Chain-of-custody forms and seals
- Coolers
- Ice
- Decontamination supplies and equipment
- Canvas or plastic sheet
- Spatula
- Scoop
- Plastic or stainless steel spoons
- Trowel
- Continuous flight (screw), bucket, or post hole auger
- Extension rods
- T-handle
- Sampling trier
- Thin-wall tube sampler
- Backhoe

Preparation

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1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner or other responsible party prior to soil sampling.

Subsurface Soil Sample Collection

Collect samples from depths with tools such as augers. The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin-wall tube sampler. The system is then lowered down the borehole, and driven into the soil at the completion depth. The system is withdrawn and the core collected from the thin-wall tube sampler.

Several types of augers available, including a bucket, continuous flight (screw), and posthole augers. Bucket augers are a better form of direct sample recovery since they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights, which are usually at 5-foot intervals. The continuous flight augers are satisfactory for use when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy soil.

The following procedures should be followed when collecting subsurface soil samples:

1. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod.
2. Clear the area to be sampled of any surface debris (i.e., twigs, rocks, litter). It may be advisable to remove the first 3 to 6 inches of the surface soil for an area approximately 6 inches in radius around the drilling location.
3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole.
4. After reaching the desired depth, slowly and carefully remove the auger from the boring. When sampling directly from the auger, collect the sample after the auger is removed from the boring and proceed to Step 10.

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5. Remove the auger tip from the drill rods and replace with a pre-cleaned thin-wall tube sampler. Install the proper cutting tip.
6. Carefully lower the tube sampler down the borehole. Gradually push the tube sampler into the soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse.
7. Remove the tube sampler, and unscrew the drill rods.
8. Remove the cutting tip and the core from the device.
9. Discard the top of the core (approximately 1 inch), as this represents material collected before penetration of the layer of concern. Place the remaining core into the appropriately labeled sample container(s)
10. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled container(s) and secure the cap(s) tightly.
11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.
12. Abandon the hole according to the applicable state regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

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SUB-GROUP	Soil Sampling Procedures				
TITLE	Shallow Subsurface and Near Surface Soil Sampling				
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INTRODUCTION

The following Standard Operating Procedure (SOP) is to describe the procedures for collecting representative surface and/or near-surface soil samples using a hand auger or other similar equipment. Analysis of soil samples may be performed to determine whether concentrations of specific soil pollutants exceed established action levels, or if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

PROCEDURE

Overview

Soil samples may be collected using a hand auger or a variety of similar methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed versus undisturbed), and the type of soil. Sampling at the surface may only require a hand trowel, while sampling at depth may be performed using a hand auger or push tube sampler.

Sample Preservation

Refrigeration to $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$, supplemented by a minimal holding time, is suggested.

Interferences and Potential Problems

There are two primary interferences or potential problems associated with soil sampling: cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated (disposable) sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results. Homogenization may also affect sample representativeness when the analytical requirements include volatile organic compounds.

Equipment or Apparatus

The equipment selected for the sampling effort may include the following as appropriate:

- Tape measure
- Survey stakes or flags
- Stainless steel, plastic, or other appropriate homogenization bucket or bowl
- Ziploc plastic bags
- Logbook
- Labels
- Chain-of-custody forms and seals
- Coolers
- Ice
- Decontamination supplies and equipment (i.e. brushes and buckets)
- Canvas or plastic sheeting

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- Spatulas
- Scoops
- Plastic or stainless steel spoons
- Trowel
- Auger bucket
- Extension rods
- T-handle

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment from the list above. Additional equipment may be added to this list as appropriate to perform other sampling.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
5. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. The staked locations will be utility-cleared by the property owner, WESTON, or other responsible party prior to soil sampling.

Surface Soil Sample Collection

Refer to SOP 1001.01

Subsurface Soil Sample Collection

Collect samples from depths with tools such as augers. The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. When the sampling depth is reached, a second auger is used to collect the soil sample. The sample may be transferred directly from the auger bucket, or in the case of push tube samplers, extruded directly from the tube. Bucket augers and push tubes are preferred for direct sample recovery since they provide a large volume of sample in a short time.

The following procedures should be followed when collecting subsurface soil samples using a bucket auger:

1. Attach the auger bit (bucket) to a drill rod extension, and attach the “T” handle to the drill rod.
2. Clear the area to be sampled of surface debris (i.e., twigs, rocks, litter). It may be advisable to remove the first 3 to 6 inches of the surface soil for an area approximately 6 inches in radius around the drilling location to prevent surficial debris from falling into the hole.

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3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheeting spread near the hole.
4. After reaching the desired depth, use a clean bucket auger/push tube to slowly and carefully collect the soil sample and remove from the subsurface.
5. Discard the top of the core (approximately 1 inch), as this may represent (slough) material collected before penetration of the layer of concern. Place the remaining core into the appropriately labeled sample containers.
6. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled container(s) and secure the cap(s) tightly. It should be noted that high plasticity clays may be difficult to homogenize. In this case, quartering of a few inches of sample core should be performed, mixed, and the pieces placed directly into the appropriate sample containers.
7. If another sample is to be collected in the same hole, but at a greater depth, reattach (if necessary) the auger bit to the drill and assemble, and follow steps 3 through 6, making sure to decontaminate the auger between sampling intervals as required for the project.
8. Abandon the hole according to the applicable state regulations. This may involve containing the soil cuttings removed from the shallow hole in labeled drums or containers and sealing the hole to the surface. Generally, shallow holes can simply be backfilled with the removed soil material. In some cases bentonite chips or pellets may be required to seal the hole to the surface.
9. Record applicable information into the field logbook or appropriate forms as documentation of sampling.

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GROUP	Sampling Procedures				
SUB-GROUP	Soil Sampling Procedures				
TITLE	Subsurface Soil Sampling – Hollow-Stem Auger Drilling Rig; Geoprobe® Sampler				
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INTRODUCTION

The following Standard Operating Procedure (SOP) is to describe the procedures for collecting representative soil samples when using hollow-stem auger drilling equipment or Geoprobe® sampling. Analysis of soil samples may determine whether concentrations of specific soil pollutants exceed established action levels, or if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

PROCEDURE

Soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed versus undisturbed), and the type of soil. Sampling at depth may be performed using hollow-stem auger drilling equipment or Geoprobe®.

Sample Preservation

Refrigeration to 4°C, supplemented by a minimal holding time, is suggested.

Interferences and Potential Problems

There are two primary interferences or potential problems associated with all soil sampling: cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practicable, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in changing the characteristics of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

Equipment or Apparatus

- Compass
- Tape measure
- Survey stakes or flags
- Stainless steel, plastic, or other appropriate homogenization bucket or bowl
- Ziploc plastic bags
- Logbook
- Labels
- Chain-of-custody forms and seals
- Coolers
- Ice
- Decontamination supplies and equipment
- Canvas or plastic sheet
- Spatula
- Scoop
- Plastic or stainless steel spoons
- Trowel
- Hollow-stem auger drilling rig and equipment
- Geoprobe® equipment
- Thin-wall tube sampler

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Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner or other responsible party prior to soil sampling.

Sample Acquisition

Hollow-stem Auger:

Soil samples may be collected when drilling with hollow-stem augers using a variety of methods. These methods include: split-spoon, thin-wall tubes, and cuttings from the auger flights.

It is difficult to determine accurately the depths from which cuttings collected from the auger flights originated and samples from these cuttings are discouraged. General logging of the types and general characteristics of penetrated soils may be accomplished using cuttings but care must be taken to limit the representation of how precisely depths and soil types are known using this technique. As a rule, environmental samples will not be collected from cuttings.

The type of sampling equipment (e.g., split-spoon, thin-wall) available on the drilling rig will determine how the samples are collected. This equipment is discussed further in the following paragraphs:

- Split-spoon: These samplers are generally driven (though they may be pushed) using a 140-pound hammer on the “cat” line. The sample is generally 18 inches or 24 inches long and about 1 inch in diameter. It is retrieved from the sampler by removing the “shoe” from the bottom and the “crossover” from the top and separating the sample tube into its two halves. The sample may be placed onto the clean logging table, left in one of the tube halves, or placed into a clean split piece of PVC pipe. The soils are then given to the logger for sample classification and retrieval of the sample aliquot.
- Thin-wall sampler: These samplers are of two general types. One type includes attaching a sampler to a rod, inserting it into the auger when the selected sample depth is reached, and pushing the sampler into the bottom of the hole generally about 2 feet or to refusal. The other type is a system in which a tube is locked into the auger bit and remains there while a sample interval is drilled out. The soil sample comes up in the tube during drilling and the tube is

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retrieved when full (generally every 5 feet). In either case the sample is extruded using either a hand jack or a hydraulically operated extruder on the drill rig. The sample is generally about 3 inches in diameter and is extruded into a clean split piece of PVC pipe for sample classification and retrieval of the sample aliquot as described below.

Geoprobe® Sampler:

The Geoprobe® sampling tool consists of a steel shoe, and sample tube attached to the bottom of a string of rod that is pushed/driven into the ground with or without drilling a pilot hole. In normal practice the geoprobe is advanced a specified distance (generally 4 feet at a time) termed a push. During each push soil from the interval enters the tube which is lined with a plastic sleeve. At the end of the push the sleeve is removed from the tube and given to the logger. The logger cuts open the sleeve and classifies the soils and removes the sample aliquot(s) as described below.

Sample Classification

The soils will be classified based on the requirements of the site-specific Sampling and Analysis Plan, Quality Assurance Project Plan, or similar document (“the plan”).

Generally, the sample will be examined using the following procedures. The sample will be scraped to remove discoloration, smeared soils, muddy water, etc. from the sample surface and examined for the following characteristics:

- Soil Type (USCS Classification)
- Color
- Moisture
- Staining
- Odors

If specified in the plan, the sample may be evaluated for environmental properties such as the presence of organic vapors by a prescribed method. These methods are generally either “cracking open” the core with a knife or spatula and inserting the probe of the organic vapor detector in the crack, or placing a portion of the sample in a sealable container (plastic “zip-lock” bag or jar covered with foil or plastic wrap) for a specified length of time after which the “head space” is checked with the detector.

Selection, Removal and Packaging of the Sample Aliquot

If a sample aliquot is to be retained for laboratory analyses, the method of selecting the materials comprising the aliquot will depend on the depth range the sample is supposed to represent, and the analyses to be run.

- If the aliquot is to represent the entire sampled interval, a pie-slice wedge should be cut out of the sample for the entire length of the sample.
- For all constituents except volatile organic compounds, the resulting volume of soil should be homogenized, if necessary, to reduce the volume to match that of the sample containers, placed in the required containers, and preserved and shipped according to the plan or SOP requirements.

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- If volatile organic analyses are to be run on the aliquot it should not be homogenized but a portion of the slice approximating the volume of the sample container should be selected and placed in the container without disturbing the soil to any greater degree than necessary.
- If the sample is to represent a discrete depth (i.e., 5 feet instead of 5 to 7 feet), then the sample should be cut out of the core at the prescribed depth cut up into appropriate sizes and placed in the sample containers.

REFERENCES

WESTON SOPs

- 0110.01 Sample Nomenclature
- 1001.02 Subsurface Soil Sampling-Drilling
- 1005.01 Field Duplicate Collection
- 1005.02 Rinse Blank Preparation
- 1005.03 Field Blank Preparation

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GROUP	Sampling Procedures				
SUB-GROUP	Surface Water				
TITLE	Surface Water Sampling				
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INTRODUCTION

The following Standard Operating Procedure (SOP) is to describe the procedures for collecting representative surface water samples. Analysis of surface samples may determine whether concentrations of specific soil pollutants exceed established action levels, or if the concentrations of pollutants present a risk to public health, welfare, or the environment.

PROCEDURE

Surface water samples may be collected using a variety of methods and equipment. The methods and equipment used are usually dependent on the location of the body of water being sampled. Sampling can be performed by merely submerging the sample container, a weighted-bottle sampler with stopper, a bailer, or by pump assisted methods. Several types of pumps can be used for sampling depending on the objectives of sampling and the site conditions.

Sample Preservation

Samples are to be preserved in conformance with the site-specific Quality Assurance Project Plan, Sampling and Analysis Plan or work plan. In general these requirements include refrigeration to 4°C, addition of appropriate additives (HCl, H₂SO₄, NaOH) to adjust and fix pH, and a defined maximum holding time. If a site-specific plan is not available, the analytical laboratory should be consulted for the appropriate preservation procedures.

Interferences and Potential Problems

There are two primary interferences or potential problems associated with surface water sampling: cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, undue disturbance of the sample matrix, or improper sample location.

Equipment or Apparatus

- Ziploc plastic bags
- Logbook
- Labels
- Chain-of-custody forms and seals
- Coolers
- Ice
- Decontamination supplies and equipment
- Discharge tubing
- Sample containers
- Sampling devices

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GROUP	Sampling Procedures				
SUB-GROUP	Surface Water				
TITLE	Surface Water Sampling				
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Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

Surface Water Sampling

Samples from shallow depths can be readily collected by merely submerging the sample container. In flowing surface water bodies, the container's mouth should be positioned so that it faces upstream, while the sampling personnel stand downstream so as not to stir up sediment that could potentially contaminate the sample.

Collecting a representative sample from a larger body of surface water requires that samples be collected near the shore unless boats are feasible and permitted. If boats are used, the body of water should be cross sectioned, and samples should be collected at various depths across the body of water in accordance with the specified sampling plan. For this type of sampling, a weighted-bottle sampler is used to collect samples at a predetermined depth. The sampler consists of a glass bottle, a weighted sinker, a bottle stopper, and a line that is used to open the bottle and to lower and raise the sampler during sampling. The procedure for use is as follows:

- Assemble the weighted bottle sampler.
- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely.
- Pull out the stopper with a sharp jerk of the sampler line.
- Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.
- Raise the sampler and cap the bottle.
- Wipe the bottle clean. The sampling bottle can be also be used as the sample container for shipping.

Teflon bailers have also been used where feasible for collecting samples in deep bodies of water.

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Another method of extending the reach of sampling efforts is the use of a small peristaltic pump. In this method the sample is drawn through heavy-wall Teflon tubing and pumped directly into the sample container. This system allows the operator to reach into the liquid body, sample from depth, or sweep the width of narrow streams.

The general sampling procedures are listed below:

1. Collect the sample using whichever technique, submerged bottle, bottle sampler with stopper, pump & tubing, or bailer.
2. The collected sample may be collected in the sample containers or may be transferred to the appropriate sample containers in order of the volatile organics first and inorganics last.
3. Label sample containers, place on ice in a cooler, remove, and decontaminate equipment as necessary.

REFERENCES

SOP 0110.01 Sample Nomenclature
SOP 1005.01 Field Duplicate Collection
SOP 1005.02 Rinse Blank Preparation
SOP 1005.03 Field Blank Preparation
SOP 1101.01 Sample Custody - Field
SOP 1102.01 Sample Shipping
SOP 1201.01 Sampling Equipment Decontamination
SOP 1501.01 Field Logbook

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GROUP	Sampling Procedures				
SUB-GROUP	Water Sampling Procedures				
TITLE	Groundwater Sampling				
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INTRODUCTION

The following Standard Operating Procedure (SOP) is to describe the procedures for collecting representative groundwater samples. Analysis of groundwater samples may determine whether concentrations of specific pollutants exceed established action levels, or if the concentrations of pollutants present a risk to public health, welfare, or the environment. This SOP applies to collection of groundwater samples from monitoring wells and/or piezometers.

PROCEDURE

Groundwater samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the piezometric level from the ground surface and the particular analytes of concern. For example, deep monitoring wells are typically purged and sampled using submersible pumps and shallow monitoring wells are typically purged and sampled using bailing techniques.

Sample Preservation

Preservation depends on the particular analyte or analyte group as specified in EPA approved analytical methods. In almost all cases, cooling to $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$, supplemented by a minimal holding time is required.

Interferences and Potential Problems

There are two primary interferences or potential problems associated with groundwater sampling: cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated (disposable) sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, inadequate purging of static and potentially unrepresentative water from the well, improper purging and sampling methods (creating turbidity problems), and improper handling of samples allowing atmospheric alteration and non-representative results (i.e. volatilization).

Equipment or Apparatus

The equipment used for sampling may be selected from the following list, as appropriate:

- Water level indicator
- Drums or buckets as appropriate to contain purge water
- Ziploc plastic bags
- Logbook
- Labels
- Chain-of-custody forms and seals
- Coolers
- Ice
- Decontamination supplies and equipment
- Canvas or plastic sheet

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- Physical monitoring equipment (pH, specific conductivity, temperature, redox potential, and dissolved oxygen measuring devices)
- Bailers (disposable and non-disposable) and bailer rope
- Submersible or peristaltic pumps and associated tubing
- Power supply as appropriate for the selected pump
- Sample containers

Preparation

1. Determine the purpose of the sampling effort, the sampling methods to be employed, and what equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment from the list above.
3. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.
4. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
5. Decontaminate or preclean equipment, and ensure that it is in working order.
6. Identify the monitoring wells to be sampled. Consider specific site factors, including extent and nature of contaminant, when selecting sample locations.
7. Evaluate safety concerns associated with sampling that may require use of personal protective equipment and/or air monitoring.

Groundwater Sample Collection

For newly installed monitoring wells and piezometers, sampling should not be performed sooner than 24 hours after development. Prior to sampling, each well/piezometer will be purged to remove static groundwater and allow collection of representative samples. Purging can be performed by either pumping with a submersible pump or peristaltic pump or by bailing with a bailer of appropriate construction. Sampling can be performed directly by whichever method is used. If a submersible pump is used as the sampling device, it will be a variable discharge type, and sampling will be performed at low flow to avoid induced volatilization of constituents (if present) from the impellers. The following procedure will be used for monitoring well/piezometer sampling.

1. Determine the construction details (screen interval, size of borehole, length of filter pack, etc.) of each monitoring well to be sampled. This information can be obtained from well construction diagrams and/or boring logs.
2. Measure and record the static water level and total depth of the well from the top of the well casing (or identified reference point). An oil/water interphase probe will be used to determine the water level and presence of phase-separated product, if present. If phase separated product is present in the well (either NAPL or DNAPL) an evaluation will be performed as to the necessity of sampling either the well or product will be performed. In the event that accumulated sediment is identified in the wells, redevelopment may be necessary prior to sampling.
3. Determine the volume of water to be purged from the well/piezometer.

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4. Lay plastic sheeting or canvas around the well to prevent contact of the bailer line or pump cable and tubing with the ground.
5. Evacuate a minimum of three well volumes of water from the well/piezometer. Low flow purging is recommended to reduce agitation and turbidity. In general, three wetted casing plus annular volumes of water are required for successful purging. For instances of low yield, purging to dryness twice is acceptable. Measure and record pH, specific conductivity, temperature and any other indicators of interest throughout purging activities. Purging is considered complete when the volume requirements are satisfied, the physical measurements stabilize (typically 0.5 pH units, 10% specific conductivity, and 1° C temperature), and when the evacuated water is reasonably free of sediment.
6. Allow the well to recover (ideally 75% of the static level), and collect the appropriate groundwater samples. A variable discharge submersible pump, peristaltic pump, or disposable bailer can be used to collect the groundwater samples. All groundwater samples will be collected and transferred to the appropriate labeled sample containers, preserved as necessary, and placed in a cooler with ice.
7. Record applicable information into field log book or appropriate forms as documentation of sampling.
8. Properly package and ship samples to the designated laboratory as soon as possible (typically the same day as collected) following proper chain-of-custody and shipping procedures.

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SUB-GROUP	Water Sampling Procedures				
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INTRODUCTION

The following Standard Operating Procedure (SOP) is to describe the procedures for collecting representative groundwater samples using low-flow groundwater sampling procedures. Analysis of groundwater samples may determine whether concentrations of specific pollutants exceed established action levels, or if the concentrations of pollutants present a risk to public health, welfare, or the environment. This SOP applies to collection of groundwater samples from monitoring wells and/ or piezometers.

Groundwater samples collected by the low-flow method are indicative of mobile organic and inorganic substances (total and dissolved) at ambient flow conditions. This SOP emphasizes the need to minimize stress via low water-level drawdowns, and low pumping rates (usually less than 1 liter/ minute) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed at collecting samples from monitoring wells having a screen or open interval length of ten (10) feet or less by utilizing a submersible or peristaltic pump. However, this procedure is flexible and can be used in a variety of well construction and groundwater yield situations. Samples thus obtained are suitable for analyses of groundwater contaminants [volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides/ polychlorinated biphenyls (pest/ PCBs), metals, cyanide, and other inorganics], or other naturally occurring analytes. This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and/or DNAPLs).

ACRONYM LIST

cc	-	Cubic centimeters
CLP	-	Contract Laboratory Program
COC	-	Chain-of-custody
°C	-	Degrees Celsius
DAS	-	Delivery of Analytical Services
DNAPL	-	Dense non-aqueous phase liquids
DO	-	Dissolved oxygen
DOT	-	Department of Transportation
Dupl	-	Duplicate
EPA	-	U.S. Environmental Protection Agency
ft	-	Feet
FID	-	Flame ionization detector
GPS	-	Global Positioning System
HASP	-	Health and Safety Plan
HCl	-	Hydrochloric Acid
HNO ₃	-	Nitric Acid

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IATA	-	International Air Transport Association
LNAPL	-	Light non-aqueous phase liquids
ml	-	Milliliter
MS/MSD	-	Matrix Spike/ Matrix Spike Duplicate
NaOH	-	Sodium Hydroxide
NTU	-	Nephelometric Turbidity Unit
ORP	-	Oxidation reduction potential
OSHA	-	Occupational Safety and Health Administration
Pest/PCB	-	Pesticide/ Polychlorinated Biphenyl
PE	-	Performance evaluation
PID	-	Photoionization detector
PPE	-	Personal Protective Equipment
ppm	-	Parts per million
PRP	-	Potentially Responsible Party
QAPP	-	Quality Assurance Project Plan
QA/ QC	-	Quality Assurance/Quality Control
RFP	-	Request for Proposal
SDG	-	Sample Delivery Group
SOP	-	Standard Operating Procedure
SVOC	-	Semivolatile Organic Compound
TDD	-	Technical Direction Document
TWP	-	Task Work Plan
µm	-	Micrometers
VOC	-	Volatile Organic Compound
WESTON	-	Roy F. Weston, Inc.
YSI Meter	-	Multi-Parameter Flow-Through Monitoring System Meter

PROCEDURE

Interferences

The primary goal of low-flow groundwater sampling is to obtain a representative sample of the groundwater at ambient flow conditions. Analysis can be compromised by field personnel in two primary ways: collecting a non-representative sample or cross-contamination of the sample.

When collecting groundwater samples using the low-flow method, stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. A non-representative sample can result from the collection of a sample prior to the stabilization of indicator field parameters. Cross-contamination of the sample can be eliminated or minimized through the

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use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary.

Personnel Qualifications

Only qualified WESTON-related personnel will conduct low-flow groundwater sampling. Training includes reviewing this SOP and other applicable SOPs and/ or guidance documents, instrument calibration training, health and safety training, and “hands-on” experience conducting groundwater sampling activities with more experienced WESTON personnel.

Apparatus and Materials

Equipment and materials used for collecting groundwater samples using the low-flow method include, but are not limited to, the following:

- Site-specific QAPP
- SOP for Low-Flow Groundwater Sampling
- Safety equipment specified in the site-specific HASP
- Field map of the site
- Monitoring well construction information (if available)
- Field logbook
- Field data sheets (for recording groundwater parameters)
- Tape measure
- Compass
- Camera and film
- Calculator
- Stop watch
- Barometer
- Keys for well cap locks
- Photoionization Detector (PID) or Flame Ionization Detector (FID)
- YSI 6-Series Multi-Parameter Flow-Through Monitoring System Meter
- Calibration fluids for YSI Meter
- Turbidity meter
- Calibration kit for turbidity meter
- Water level indicator
- Submersible pump (if applicable)
- Peristaltic pump (if applicable)
- Generator
- Extension cords
- Tygon tubing

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- Peristaltic tubing
- In line filters
- Graduated cylinder (1 to 2 liters preferably)
- Plastic beakers (1 liter)
- Three way valves
- 5-Gallon buckets
- Decontamination fluids (supplies)/equipment (pump sprayers, brushes, etc.)
- Plastic sheeting
- Plastic tubs
- Sample containers
- pH paper
- Performance evaluation (PE) samples
- Chain-of-custody (COC) forms and seals
- Sealable plastic bags
- Labels
- Trash bags
- Coolers and ice
- Vermiculite
- Tape (duct, packing, and strapping)

Reagents

Reagents used for the preservation of groundwater samples include hydrochloric acid, nitric acid, and sodium hydroxide. Sampling preservation methods are further discussed in *Section 10.0, Sample Containers, Preservation, Handling, and Storage*.

Method Calibration

The manufacturers instructions for specific use of the YSI 6-Series Multi-Parameter Flow-Through Monitoring System Meter (YSI Meter) will be followed.

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Sample Collection

Preparation

A pre-sampling meeting will be held to discuss the proposed sampling strategy and site health and safety issues. Attendees of the pre-sampling meeting may include the Project Leader, Site Leader, Program Manager or Deputy Program Manager, samplers, and the Health and Safety Officer. During the pre-sampling meeting, the Site Leader discusses the site history, contaminants of concern, sampling methodology, individual responsibilities, sample shipment or delivery, health and safety issues, and lines of communication anticipated during the sampling event.

Prior to mobilizing to the site to conduct sampling activities, an equipment/ supply list will be completed and provided to the WESTON equipment store. Necessary sampling equipment, sample containers, personnel protective equipment (PPE), and vehicles are therefore reserved.

Low-Flow Groundwater Sampling

The YSI Meter will be calibrated by the sampling team. The samplers will decontaminate the sampling equipment (if appropriate). Decontamination will be conducted in accordance with the HASP and/or applicable SOPs.

Preliminary Well Observations

Prior to sampling a monitoring well, personnel will check the well for security damage or evidence of tampering, and will record pertinent observations. Personnel will remove the well cap and will immediately screen the headspace of the well for VOCs with a PID or FID, and record the reading in the field logbook. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), personnel will make one and record the location and date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any sampling activities begin. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Newly constructed wells will be checked for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent measurements with an interface probe are usually not needed unless analytical data or field headspace information signal a

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worsening situation. [Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP].

Purging Procedures

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (peristaltic), and/ or the use of dedicated sampling equipment.

Lower the submersible pump or tubing (when using a peristaltic pump) slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. If possible, keep the pump intake or tubing at least 2 feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Prior to starting the submersible pump or peristaltic pump, measure the water level in the well. If possible, leave the water level meter in the well while purging in order to more effectively determine drawdown of the water column.

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check the water level and adjust the pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize. Monitor and record water level and pumping rate every five (5) minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1 to 0.4 liter/minute) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen (15) minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then “recover” as pump flow adjustments are made.

Purge volume calculations should utilize the stabilized drawdown value, not the initial drawdown. **Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen).** The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Monitoring Parameters

All parameter measurements, except turbidity, must be obtained using a flow-through-cell. During well purging, monitor indicator field parameters (turbidity, temperature, pH specific conductance, ORP, and DO) every 5 minutes (or less frequently, if appropriate). [Note:

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During the early phase of purging, emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments]. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at 5-minute intervals, are within the following limits:

- Turbidity (10% for values greater than 1 NTU)
- Temperature (3%)
- pH (± 0.1 unit)
- Specific conductance (3%)
- ORP (± 10 millivolts)
- Specific conductance (3%)
- DO (10%)

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than five (5) Nephelometric Turbidity Units (NTU) and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging, indicator field parameters have not stabilized, one of three optional courses of action may be taken:

- Continue purging until stabilization is achieved.
- Discontinue purging, do not collect any samples, and record in the logbook that stabilization could not be achieved (documentation must describe attempts to achieve stabilization).
- Discontinue purging, collect samples, and provide full explanation of attempts to achieve stabilization. (Note: There is a risk that the analytical data obtained, especially for metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

Collection of Samples

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During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4-inch or 3/8-inch (inside diameter) tubing be used to help ensure that the sample tubing remains filled with water. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples:

- Add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing.
- Insert small diameter Teflon tubing into water-filled portion of pump tubing, allowing the end to protrude beyond the end of the pump tubing, and collect sample from small diameter tubing.

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- Collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing; collect sample and record new drawdown, flow rate, and new indicator field parameter values.

Groundwater samples for laboratory analyses must be collected before the water has passed through the flow-through-cell (e.g., use a three-way valve prior to the flow-through-cell). The VOC samples will be collected first, followed by SVOCs, metals, and cyanide samples.

The collection of VOC samples requires minimal disturbance of the sample to limit volatilization and therefore a loss of volatiles from the sample. The following procedures must be followed while collecting the VOC fraction of the sample.

- Open the vial, set the cap in a clean place, and collect the sample by allowing the water to flow gently down the inside of the container with minimal disturbance of the sample to limit volatilization and therefore prevent loss of volatile compounds from the sample. VOC samples shall not be collected and/or preserved near a running motor or any type of exhaust system due to possible contamination by discharges, fumes or vapors. Each container will be preserved with five drops of 1:1 hydrochloric acid (HCl) per 20 ml of sample so that the pH is < 2. To collect a sample, open the container, set the cap in a clean place, and collect the sample. When collecting replicate samples, collect both samples at the same time. Fill the container to just overflowing until there is a convex meniscus on the top of the container. Check that the cap has not been contaminated (splashed) and carefully cap the container. Place the cap directly over the top and screw down firmly. Do not overtighten and break the cap. The sealed container will be inverted, tapped gently on the side, and observed for 10 seconds for the presence of air bubbles. If an air bubble appears, the sample will be discarded and the collection procedure repeated. The sample containers will then be shaken vigorously to mix the preservative; placed in a resealable plastic bag; and placed into a cooler with ice. The holding time for VOC samples is 7 days. Samples should be shipped or delivered to the laboratory daily so as not to exceed the holding time. Ensure that the samples remain at 4 degrees celsius (°C), but do not allow them to freeze.

One trip blank sample (organic-free water) will be collected prior to the sampling event.

SVOC Sampling - Samples will be collected by allowing the water to flow gently down the inside of the appropriate size glass containers. Cap the sample container tightly and place pre-labeled sample container in a cooler with ice.

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Pesticides/PCBs Sampling - Samples will be collected by allowing the water to flow gently down the inside of the appropriate size glass containers. Cap the sample container tightly and place pre-labeled sample container in a cooler with ice.

Metals Sampling - Samples will be collected by allowing the water to flow gently down the inside of the appropriate glass or plastic containers and preserving with nitric acid (HNO₃) to a pH of < 2. Cap the sample container tightly and place pre-labeled sample container in a cooler with ice.

Cyanide (Total and Amenable) Sampling - Samples will be collected by allowing the water to flow gently down the inside of the appropriate glass or plastic containers and preserved with sodium hydroxide (NaOH) to a pH of > 12. Cap the sample container tightly and place pre-labeled sample container in a cooler with ice.

If (dissolved) metal concentrations is a sampling objective, then filtered water samples will be collected using the same low-flow method. The use of an in-line filter is required, and the filter size [0.45 micrometers (µm) is commonly used] should be based on the sampling objective. Pre-rinse the filter with approximately 25 to 50 ml of groundwater prior to sample collection. Preserve the filtered water sample immediately. [Note: Filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health risk calculations].

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. [Note: Measurement of total well depth is optional after the initial low stress sampling event; however, it is recommended if the well has a “silting” problem or if confirmation of well identity is needed].

Secure the well by installing the riser cap, and placing a padlock on the protective casing cap.

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Handling and Preservation

The type of analysis for which a sample is being collected determines the type of bottle, preservative, holding time, and filtering requirements. Ideally, sample containers will be labeled appropriately prior to sample collection; however, if this is not possible, sample containers will be labeled immediately after sample collection.

Trip blanks are used to assess the degree of contamination introduced into samples during sample handling, shipment, and analysis. Contamination may be introduced from the sample bottle, the preservatives used, cross-contamination (in the case of VOCs), or from shipping and handling, both in the field and in the laboratory. Samples are shipped to analytical laboratories expeditiously to ensure that holding times are not exceeded. Chemical preservatives used during groundwater sampling activities include HCl, HNO₃, and NaOH.

Preservative will be added, as required by analytical methods, to samples after they are collected, if the sample containers are not pre-preserved. VOC samples (collected in 40-ml vials) are pre-preserved with 10 drops of HCl. HNO₃ will be added (following sample collection) to samples collected for metals (total or dissolved) analyses until a pH of less than 2 is obtained. NaOH will be added (following sample collection) to samples collected for cyanide analyses until a pH of greater than 12 is obtained.

Following preservation, sample information will be recorded on the appropriate chain of custody form, and samples will be placed in a cooler to be maintained at 4°C. Samples must be shipped before the holding time is over, ideally within 24 hours of sample collection. It is imperative that these samples be shipped or delivered daily to the analytical laboratory in order to maximize the time available for the laboratory to perform the analysis. The bottles should be shipped with adequate packing and cooling material to ensure that they arrive intact and at 4°C.

Troubleshooting

All field screening instrumentation (PID and/ or FID, and YSI meter) and pumps must be calibrated and operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the site-specific QAPPs. Equipment checkout and calibration activities must occur prior to and following sampling activities, and they must be documented.

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Data Management and Records Management

Field observations made during the sampling event will be recorded in a site logbook, including description of sampling locations and any deviations from the site-specific QAPPs.

Chain-of-custody will be maintained until samples are relinquished to a courier or to the laboratories assigned to perform the analyses. Photographs may be taken to document site conditions. The location and direction from which photographs are taken will be noted in the field logbook, in accordance with the scope of work. Reports, site file memoranda, figures, tables, boring logs, etc. will be saved in site-specific project files.

Reference Section

U.S. Environmental Protection Agency. April 1996. *Region I, Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures*. EPA. 1996. (EPA/540/S-95/504)

SOP	1005.01				
GROUP	Sampling Procedures				
SUB-GROUP	Field QA/QC Sampling				
TITLE	Field Duplicate Collection				
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INTRODUCTION

The following Standard Operating Procedure (SOP) describes the procedure for collecting field duplicate soil and water samples. When samples are collected for analysis, it is typically desired that independent data allowing evaluation of laboratory precision (i.e., the degree to which a laboratory result can be repeated) on site-specific samples be collected.

A field duplicate sample is a second sample collected at the same location as the original sample. Duplicate samples are collected simultaneously or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. The sample containers are assigned an identification number in the field such that they cannot be identified (blind duplicate) as duplicated samples by laboratory personnel performing the analysis. Specific locations are designated for collection of field duplicate samples prior to the beginning of sample collection.

The duplicate soil sampling procedure is closely related to SOP Nos. 1001.01, 1001.03, and 1001.10 regarding soil sampling procedures. This procedure serves as an alternative method or extension of sample preparation prior to placing the samples in containers, as described in the 1001 series of the SOPs (e.g. 1001.01 and 1001.03).

DUPLICATE SOIL SAMPLING PROCEDURE

The procedure to be used to physically collect soil samples are described in SOP Nos. 1001.01 and 1001.03. Reference should be made to these SOPs for specific sampling equipment, procedures, and other general guidelines. As soil is collected, the following procedure will be used to prepare a field duplicate sample:

- The soil will be collected in general accordance with SOP 1001.01 or 1001.03, with the exception that samples will generally not be immediately placed into sample containers and an additional preparation step (i.e., sample splitting) will be performed.
- As they are collected, soil samples to be submitted as field duplicates will be staged in a clean mixing bowl or mixing bucket.
- For samples that will be analyzed for volatile organic compounds, the soil sample will be split in half and an equal portion of soil will be placed directly into two or more different sample containers, each container representing a different sample for laboratory analysis. The soil will not be homogenized to minimize the potential for volatilization of the organic compounds potentially in the sample.
- For analyses of chemicals other than volatile organic compounds, the soil removed from the discrete sample location will be homogenized in a clean mixing bowl using a clean scoop or spatula (as described in SOPs 1001.01 and 1001.03). Homogenization will generally continue until the discrete samples being combined are reasonably indistinguishable as individual samples in the soil mixture. However, it is recognized that homogenization can be difficult for highly plastic clays. In this case, equal amounts of the soil core of each clay sample will be cut into small, roughly cubical pieces using a stainless steel knife and placed into a bowl and homogenized to extent practical.

SOP	1005.01				
GROUP	Sampling Procedures				
SUB-GROUP	Field QA/QC Sampling				
TITLE	Field Duplicate Collection				
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- The field duplicate sample (except for volatiles as note above) will be collected from the mixing bowl containing the homogenized samples after homogenization is performed. The composited sample will be collected using a stainless steel or disposable plastic scoop or similar tool. The sample will be placed in a clean sample container and then handled in accordance with soil sampling SOPs 1001.01 and 1001.03.

Another difference from the referenced SOPs is that additional soil volume may need to be collected from a discrete sample location during the sampling process to provide sufficient sample volume for two or more sets of laboratory analyses. If the collection of additional sample volume will result in the sample interval expanding to greater depths or laterally outward, the sampling tools identified in 1001 series of the SOPs can be used at two immediately vertically or laterally adjacent locations, as appropriate. If sampling from two adjacent but distinct locations is necessary to obtain adequate sample volume, the soil from the two locations should be composited in accordance with SOP 1001.10. Field duplicates of composited samples may also be performed using this SOP for field duplicate samples.

Variations on this procedure are allowable to accommodate different soil conditions and any site requirements specifically identified in the site-specific Sampling and Analysis Plan. Equipment that may be used as part of the soil compositing procedure is identified under SOP Nos. 1001.01 and 1001.03 where soil sampling methods are described.

DUPLICATE WATER SAMPLING PROCEDURES

The procedure to be used to physically collect water samples are described in 1002 series of the SOPs (e.g. 1002.01 and 1002.02). Reference should be made to these SOPs for specific sampling equipment, procedures, and other general guidelines. A duplicate water sample will be collected from the same location as the parent sample and within 15 minutes of the collection of the parent sample.

The number of samples that may be submitted as blind field duplicates for the project in question will be specified in the site-specific sampling plan. Blind field duplicates are typically collected at a frequency of 1 per 10 samples of a given environmental media at sites, especially where laboratory analytical data will be used for evaluating regulatory compliance and other engineering judgments. Sampling in support of a routine monitoring program may not require field duplicates. Reference should be made to the site-specific contract and work plans.

REFERENCES

SOP No. 1001.01 - Standard Operating Procedure, Surface Soil Sampling
SOP No. 1001.03 - Standard Operating Procedure, Soil Sampling - Hand Auger Method
SOP No. 1001.10 - Standard Operating Procedure, Soil Compositing

SOP	1005.03				
GROUP	Sampling Procedures				
SUB-GROUP	Field QA/QC Sampling				
TITLE	Field Blank Preparation				
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INTRODUCTION

The following Standard Operating Procedure (SOP) presents the procedure to prepare a field blank. A field blank is a type of quality control sample prepared during the collection of normal samples. The field blank consists of target analyte-free, deionized, or distilled water that is poured directly into appropriate sampling containers at a particular sampling location. These samples are then submitted to the laboratory for analyses similar those conducted for other samples collected during the investigation. The results for the field blank are evaluated to determine if sample integrity may have been compromised through air borne entry of contaminants or from the sample glassware.

PROCEDURE

A field blank will be prepared by placing (pouring) a sample of target analyte-free, deionized, or distilled water (as appropriate to the project) into a clean sample container during collection of the samples in the field. This sample will then be sealed, labeled, and placed in a cooler with other samples collected during the investigation. The field blank sample will typically be submitted to the laboratory for analysis similar to those being performed for other samples collected during the investigation.

The frequency for collecting field blanks should be determined prior to engaging in field activities, and communicated in site-specific quality assurance project plans, sampling and analyses plans, or a type of work plan. Field blanks should be collected at a rate relative to each type of sample collection procedure (i.e., groundwater, surface water). Typically, field blanks will be collected at a rate of 1 per 20 samples of a given environmental media. Reference should be made to the contract or sampling and analysis plan for site-specific requirements.

SOP	1101.01				
GROUP	Sampling Handling				
SUB-GROUP	Sample Custody				
TITLE	Sample Custody in the Field				
DATE	11/19/2001	FILE	1101-01.DOC	PAGE	1 of 4

INTRODUCTION

The following Standard Operating Procedure (SOP) presents procedures for maintaining sample chain of custody (COC) during activities where samples are collected.

PROCEDURE

Sample custody is defined as being under a person's custody if any of the following conditions exist:

- it is in their possession,
- it is in their view, after being in their possession,
- it was in their possession and they locked it up, or
- it is in a designated secure area.

A designated field sampler will be personally responsible for the care and custody of collected samples until they are transferred to another person or properly dispatched to the laboratory. To the extent practicable, as few people as possible will handle the samples.

Sample tags or labels will be completed and applied to the container of each sample. When the tags or labels are being completed, waterproof ink will be used. If waterproof ink is not used, the tags or labels will be covered by transparent waterproof tape. Sample containers may also be placed in Ziploc-type storage bags to help keep them clean in the cooler. Information typically included on the sample tags or labels will include the following:

- Project Code
- Station Number and Location
- Sample Identification Number
- Date and Time of Sample Collection
- Type of Laboratory Analysis Required
- Preservation Required, if applicable
- Collector's Signature
- Priority (optional)
- Other Remarks

Additional information may include:

- Anticipated Range of Results (Low, Medium, or High)
- Sample Analysis Priority

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GROUP	Sampling Handling				
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A COC form will be completed each time a sample or group of samples is prepared for transfer to the laboratory. The form will repeat the information on each of the sample labels and will serve as documentation of handling during shipment. The minimum information requirements of the COC form are listed in Table 1101.01-A. An example COC form is shown in Figure 1101.01-A. The completed COC must be reviewed by the Field Team Leader or Site Manager prior to sample shipment. The COC form will remain each sample shipping container at all times, and another copy will be retained by the member of the sampling team who originally relinquished the samples or in a project file.

SOP	1101.01				
GROUP	Sampling Handling				
SUB-GROUP	Sample Custody				
TITLE	Sample Custody in the Field				
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TABLE 1101.01-A CHAIN OF CUSTODY FORM

INFORMATION	COMPLETED BY	DESCRIPTION
COC	Laboratory	enter a unique number for each chain of custody form
SHIP TO	Field Team	enter the laboratory name and address
CARRIER	Field Team	enter the name of the transporter (e.g., FedEx) or handcarried
AIRBILL	Field Team	enter the airbill number or transporter tracking number (if applicable)
PROJECT NAME	Field Team	enter the project name
SAMPLER NAME	Field Team	enter the name of the person collecting the samples
SAMPLER SIGNATURE	Field Team	signature of the person collecting the samples
SEND RESULTS TO	Field Team	enter the name and address of the prime contractor
FIELD SAMPLE ID	Field Team	enter the unique identifying number given to the field sample (includes MS, MSD, field duplicate and field blanks)
DATE	Field Team	enter the year and date the sample was collected in the format M/D (e.g., 6/3)
TIME	Field Team	enter the time the sample was collected in 24 hour format (e.g., 0900)
MATRIX	Field Team	enter the sample matrix (e.g., water, soil)
PRESERVATIVE	Field Team	enter the preservative used (e.g., HNO3) or "none"
FILTERED/ UNFILTERED	Field Team	enter "F" if the sample was filtered or "U" if the sample was not filtered
CONTAINERS	Field Team	enter the number of containers associated with the sample
MS/MSD	Field Team or Laboratory	enter "X" if the sample is designated for the MS/MSD
ANALYSES REQUESTED	Field Team	enter the method name of the analysis requested (e.g., SW6010A)
COMMENTS	Field Team	enter comments
SAMPLE CONDITION UPON RECEIPT AT LABORATORY	Laboratory	enter any problems with the condition of any sample(s)
COOLER TEMPERATURE	Laboratory	enter the internal temperature of the cooler, in degrees C, upon opening
SPECIAL INSTRUCTIONS/COMMENTS	Laboratory	enter any special instructions or comments
RELEASED BY (SIG)	Field Team and Laboratory	enter the signature of the person releasing custody of the samples
COMPANY NAME	Field Team and Laboratory	enter the company name employing the person releasing/receiving custody
RECEIVED BY (SIG)	Field Team and Laboratory	enter the signature of the person receiving custody of the samples
DATE	Field Team and Laboratory	enter the date in the format M/D/YY (e.g., 6/3/96) when the samples were released/received
TIME	Field Team and Laboratory	enter the date in 24 hour format (e.g., 0900) when the samples were released/received

SOP	1101.01				
GROUP	Sampling Handling				
SUB-GROUP	Sample Custody				
TITLE	Sample Custody in the Field				
DATE	11/19/2001	FILE	1101-01.DOC	PAGE	4 of 4

FIGURE 1101.01-A CHAIN OF CUSTODY FORM

SOP	1102.01				
GROUP	Sample Handling				
SUB-GROUP	Sample Shipping				
TITLE	Sample Shipping				
DATE	11/19/2001	FILE	1102-01.DOC	PAGE	1 of 1

INTRODUCTION

The following Standard Operating Procedure (SOP) presents the procedures for sample shipping that will be implemented during field work involving sampling activities.

TERMS

COC - Chain-of-Custody

PROCEDURE

Prior to shipping or transferring custody of samples, they will be packed according to D.O.T. requirements with sufficient ice to maintain an internal temperature of $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$ during transport to the laboratory. Samples relinquished to the participating laboratories will be subject to the following procedures for transfer of custody and shipment:

1. Samples will be accompanied by a COC record. When transferring possession of samples, the individuals relinquishing and receiving the samples will sign, date, and note the time of the sample transfer on the record. If sent by common carrier, a bill of lading or airbill should be used. Bill of lading and airbill receipts will be retained in the project file as part of the permanent documentation of sample shipping and transfer. This custody record documents transfer of sample custody from the sampler to another person or to the laboratory. The designated laboratory will accept custody in the field upon sample pick-up or at the laboratory if the samples are delivered via field personnel or a courier service.
2. Samples will be properly packed in approved shipping containers for laboratory pick-up by the appropriate laboratory for analysis, with separate, signed custody records enclosed in each sample box or cooler. Sample shipping containers will be padlocked or custody-sealed for transfer to the laboratory. The preferred procedure includes use of a custody seal wrapped across filament tape that is wrapped around the package at least twice. The custody seal will then be folded over and stuck to itself so that the only access to the package is by cutting the filament tape or breaking the seal to unwrap the tape. The seal will then be signed. The designated laboratory will accept custody of the samples upon receipt.
3. Whenever samples are split with state representatives or other parties, the COC record will be marked to indicate with whom the samples were split.
4. The field sampler will call the designated laboratory to inform them of sample shipment and verify sample receipt as necessary.

SOP	1201.01				
GROUP	Decontamination				
SUB-GROUP	Sampling Equipment Decontamination				
TITLE	Sampling Equipment Decontamination				
DATE	11/19/2001	FILE	1201-01.DOC	PAGE	1 of 3

INTRODUCTION

The following Standard Operating Procedure (SOP) presents the methods used for minimizing the potential for cross-contamination, and provides general guidelines for sampling equipment decontamination procedures.

PROCEDURE

As part of the Health and Safety Plan (HASP), develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The decontamination plan should include the following:

- The number, location, and layout of decontamination stations
- Which decontamination apparatus is needed
- The appropriate decontamination methods
- Methods for disposal of contaminated clothing, apparatus, and solutions

Decontamination Methods

Personnel, samples, and equipment leaving the contaminated area of a site will be decontaminated. Various decontamination methods will be used to either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or both. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing/scrubbing the surface containing the contaminant. This method includes mechanical and wet blasting methods.

Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

Cleaning can also be accomplished by water blasting which is also referred to as steam cleaning and pressure washing. Pressure washing utilizes high-pressure that is sprayed from a nozzle onto sampling equipment to physically remove soil or (potentially) contaminated material. Steam cleaning is a modification of pressure washing where the water is heated to temperatures approaching 100°C to assist in removing organic constituents from equipment.

SOP	1201.01				
GROUP	Decontamination				
SUB-GROUP	Sampling Equipment Decontamination				
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Disinfection/Rinse Methods

Disinfectants are a practical means of inactivating chemicals or contaminants of concern. Standard sterilization methods involve heating the equipment which is impractical for large equipment. Rinsing removes contaminants through dilution, physical attraction, and solubilization.

The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be target analyte free. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions. An untreated potable water supply is not an acceptable substitute for tap water. Acids and solvents are occasionally utilized in decontamination of equipment to remove metals and organics, respectively, from sampling equipment. Other than ethanol, these are avoided when possible due to the safety, disposal, and transportation concerns associated with them.

Equipment or apparatuses that may be selected for use include the following:

- Personal protective clothing
- Non-phosphate detergent
- Selected solvents for removal of polar and nonpolar organics (ethanol, methanol, hexane)
- Acid washes for removal of metals (nitric acid)
- Long-handled brushes
- Drop cloths or plastic sheeting
- Paper towels
- Galvanized tubs or buckets
- Distilled, deionized, or tap water (as required by the project)
- Storage containers for spent wash solutions
- Sprayers (pressurized and non-pressurized)
- Trash bags
- Safety glasses or splash shield

Field Sampling Equipment Cleaning Procedures

The following procedures should be followed:

1. Where applicable, follow physical removal procedures previously described (pressure wash, scrub wash)
2. Wash equipment with a non-phosphate detergent solution
3. Rinse with tap water
4. Rinse with distilled or deionized water
5. Rinse with 10% nitric acid if the sample will be analyzed for metals/organics
6. Rinse with distilled or deionized water
7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics
8. Air dry the equipment completely
9. Rinse again with distilled or deionized water

SOP	1201.01				
GROUP	Decontamination				
SUB-GROUP	Sampling Equipment Decontamination				
TITLE	Sampling Equipment Decontamination				
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10. Place in clean bag or container for storage/transport to subsequent sampling locations.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if the analyses do not include inorganics. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, ethanol, hexane, methanol, or water. An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the ten-step decontamination procedure listed above may be modified for site specificity.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing before commencement of sampling and between sampling locations. Plastic tubing should not be reused.

SOP	1301.01				
GROUP					
SUB-GROUP					
TITLE	Subsurface Soil Logging Procedures – Weston OnLine				
DATE	11/19/2001	FILE	1301-01.DOC	PAGE	1 of 2

INTRODUCTION

The following Standard Operating Procedure (SOP) presents the standard procedures for logging subsurface soils during soil borings and/or monitor well installation. This logging procedure is based primarily on the Unified Soil Classification System (USCS).

LOGGING PROCEDURES

The soil boring logging should be recorded on the **Soil Boring & Well Construction Field Log**. If a monitoring well is installed at the boring location, the well completion diagram should be recorded on the same form.

There are two sections that must be completed. The first is a header for the log that describes the *drilling location*, methods, and observers. The second is the subsurface sampling methods and findings. This includes information about the *sampling intervals* and *depth specific data*. Information obtained and recorded for each of these sections are described below.

DRILLING LOCATION DATA

- Station ID
- Name of Logging Geologist/Engineer
- Date & Time Started
- Date & Time Finished
- Air Monitoring Instrument (OVA, HNU, Drager, etc.) and Bar-code
- Drilling Method(s) (HSA, Wet Rotary, Air Rotary, CPT, etc.)
- Drilling Company
- Borehole Diameter (i.e. Auger cutter head diameter, Rotary bit diameter)
- Monitoring Well Diameter (if installed)
- Total Depth of Borehole
- Total Depth of Monitoring Well (if installed)
- Observations (weather, materials used, etc.)
- Drilling Location Site Sketch

INTERVAL SPECIFIC DATA

- Sample Interval (beginning and ending depths)
- Sampler Type Symbol (i.e. SHB, SSP, Core Barrel, CPT Sampler, Cuttings)
- Sample Recovery (as either a % or measurement [20"/24"])

DEPTH SPECIFIC DATA

- Material Graphics Symbol
- Air Monitoring Instrument Readings
- Visual Sample Inspection and Description
- Sample Collection Information (see SOP ARCS-DM-110)

SOP	1301.01				
GROUP					
SUB-GROUP					
TITLE	Subsurface Soil Logging Procedures – Weston OnLine				
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Description Sequence:

The codes from the **Geologic Logging Codes** should be entered into the corresponding column on the **Soil Boring & Well Construction Field Log** at the appropriate depth.

Int	Sampling Interval Symbol and Recovery Information
Log	Material Graphics Symbol
Instrument	OVA or HNU Readings
USCS	USCS Soil Classification
Color	Rock or Soil Color
St	Strength
M	Moisture Content
P	Plasticity
G	Grain Size (cohesionless soils)
S	Sorting (cohesionless soils)
R	Roundness (cohesionless soils)
Sample ID	Analytical Sample ID
Remarks	Additional Observations
Well	Well Construction Symbols

Additional Observations

- nodules (calcareous or ferrous)
- natural (ferrous) staining
- contaminant staining, odors, free phase product
- roots or peat laminations
- partings, pockets, seams, laminations
- degree of dilatency (if applicable)
- structure: stratified, slickensided, laminated, blocky, fissured, lensed, homogenous

Modifiers

- use *trace* to indicate <5%
- use *few* to indicate 5 to 10%
- use *little* to indicate 15 to 25%
- use *some* to indicate 30 to 45%
- use *mostly* to indicate 50 to 100%

SOP	1501.01				
GROUP	Field Documentation				
SUB-GROUP					
TITLE	Field Logbook				
DATE	11/19/2001	FILE	1501-01.DOC	PAGE	1 of 3

INTRODUCTION

The following Standard Operating Procedure (SOP) presents the procedures for documenting activities observed or completed in the field in a field logbook. The documentation should represent all activities of WESTON personnel and entities under WESTON's supervision.

TERMS

FSP - Field Sampling Plan

SAP - Sampling and Analysis Plan

QAPP - Quality Assurance Project Plan

HASP - Health and Safety Plan

PROCEDURE

Field logbooks will be used and maintained during field activities to document pertinent information observed or completed by WESTON personnel or entities that WESTON is responsible for providing oversight. Field logbooks are legal documents that form the basis for later written reports and may serve as evidence in legal proceedings. The Site Manager or Field Team Leader will review field log entries daily and initial each page of entries. Field logbooks will be maintained by the Site Manager or Field Team Leader during field activities and transferred to the project files for a record of activities at the conclusion of the project. General logbook entry procedures are listed below.

- Logbooks must be permanently bound with all pages numbered to the end of the book. Entries should begin on page 1.
- Only use blue or black ink (waterproof) for logbook entries.
- Sign entries at the end of the day, or before someone else writes in the logbook.
- If a complete page is not used, draw a line diagonally across the blank portion of the page and initial and date the bottom line.
- If a line on the page is not completely filled, draw a horizontal line through the blank portion.
- Ensure that the logbook clearly shows the sequence of the day's events.
- Do not write in the margins or between written lines, and do not leave blank pages to fill in later.
- If an error is made, make corrections by drawing a single line through the error and initialing it.
- Maintain control of the logbook and keep in a secure location.

SOP	1501.01				
GROUP	Field Documentation				
SUB-GROUP					
TITLE	Field Logbook				
DATE	11/19/2001	FILE	1501-01.DOC	PAGE	2 of 3

Field logbooks will contain, at a minimum, the following information, if applicable:

General Information

- Name, location of site, and work order number
- Name of the Site Manager or Field Team Leader
- Names and responsibilities of all field team members using the logbook (or involved with activities for which entries are being made)
- Weather conditions
- Field observations
- Names of any site visitors including entities that they represent

Sample Collection Activities

- Date(s) and times of the sample collection or event.
- Number and types of collected samples.
- Sample location with an emphasis on any changes to documentation in governing documents (i.e., SAP, FSP). This may include measurements from reference points or sketches of sample locations with respect to local features.
- Sample identification numbers, including any applicable cross-references to split samples or samples collected by another entity.
- A description of sampling methodology, or reference to any governing document (i.e., FSP, SAP, QAPP).
- Summary of equipment preparation and decontamination procedures.
- Sample description including depth, color, texture, moisture content, and evidence of waste material or staining.
- Air monitoring (field screening) results.
- Types of laboratory analyses requested.

Site Health and Safety Activities

- All safety, accident, and/or incident reports.

SOP	1501.01				
GROUP	Field Documentation				
SUB-GROUP					
TITLE	Field Logbook				
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- Real-time personnel air monitoring results, if applicable, or if not documented in the HASP.
- Heat/cold stress monitoring data, if applicable.
- Reasons for upgrades or downgrades in personal protective equipment.
- Health and safety inspections, checklists (drilling safety guide), meetings/briefings.
- Calibration records for field instruments.

Oversight Activities

- Progress and activities performed by contractors including operating times.
- Deviations of contractor activities with respect to project governing documents (i.e., specifications).
- Contractor sampling results and disposition of contingent soil materials/stockpiles.
- Excavation specifications and locations of contractor confirmation samples.
- General site housekeeping and safety issues by site contractors.

SOP	1502.01				
GROUP	Field Documentation				
SUB-GROUP					
TITLE	Photograph Logs				
DATE	11/19/2001	FILE	1502-01.DOC	PAGE	1 of 1

INTRODUCTION

The following Standard Operating Procedure (SOP) presents the requirements for collecting information related to photodocumentation of site activities.

PROCEDURE

- Uniquely number each roll of film obtained for use.
- Record the following information for each negative exposed:
 1. Date and Time
 2. Photographer Name
 3. Witness Name
 4. Orientation (Landscape, Portrait, or Panaoramic)
 5. Description (including activity being performed, specific equipment of interest, sample location(s), compass direction photographer is facing)
- Record "NA" for the negatives not used if the roll is not completely used prior to development.
- Record unique roll number on receipt when film is submitted for development.
- Verify descriptions on log with negative numbers when photographs are received from processing.

FORMS

Blank Photograph Logs can be printed from WESTON On-Line from the *Records Management Application*. Selecting the *Reports/Project Planning/Blank Photo Logs* menu option will generate a project specific log with 36 entries.

APPENDIX D

TDD NOs. 35/WESTION-042-14-001 AND 19/WESTON-042-13-001